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Background Study 53

The Uneasy Eighties

The Transition to an Information Society

Arthur J. Cordell

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Arthur J. Cordell

After graduating from McGill University with a BA in economics and psychology, Arthur Cordell went on to study economics at Cornell University, receiving an MA in 1963 and a PhD in 1965. In 1968, he joined the Science Council of Canada as a science adviser. He has authored a number of studies for the Science Council, including Background Study 22, *The Multinational Firm, Foreign Direct Investment and Canadian Science Policy* (1971) and Background Study 35, *The Role and Function of Government Laboratories and the Transfer of Technology to the Manufacturing Sector* (coauthored with James M. Gilmour, 1976). In addition, Dr Cordell has directed several of the Council's research efforts, most notably those that examined the social and economic impacts of microelectronics and computers.

Prior to joining the Science Council, Dr Cordell served as a staff economist with a U.S. presidential commission in Washington, D.C. He has worked as a business economist and consultant, and as an assistant manager of economic analysis with General Foods Corporation of White Plains, New York. Dr Cordell has published articles on economic theory and international trade, and has lectured on multinational corporations, environmental indicators and economic growth, and on the implications of information technology for Canadian society.

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Foreword

In 1978, the Science Council of Canada established a committee on computers and communications to review developments in microelectronics and their probable effects on employment, industry, education, research, society, and the individual. Between 1978 and 1981, the committee issued its findings in a series of publications, including *Communications and Computers: Information and Canadian Society* (1978), *A Scenario for the Implementation of Interactive Computer-Communications Systems in the Home* (1979), *The Impact of the Microelectronics Revolution on Work and Working* (1980), *The Impact of the Microelectronics Revolution on the Canadian Electronics Industry* (1981), and *Policy Issues in Computer-Aided Learning* (1981).

Despite these efforts, however, the committee became concerned that leaders in government, industry, and education were not acting with sufficient speed to prepare for, and to take advantage of, the enormous changes taking place in many Western industrialized nations as a result of the microelectronics revolution. The committee therefore issued Report 33, *Planning Now for an Information Society: Tomorrow is too Late,* in April 1982. In it, the committee outlined 27 specific measures that governments and leaders in education and industry could take to ensure Canada's long-term success as an international competitor in the research, production, and marketing of products related to the new technologies, as well as economic and social stability at home during the transition to an information society. Only through planning and immediate action, the report argued, could the effects of the new technologies be controlled, so that their use would contribute to the overall wellbeing of Canadians. The result of inaction, the report warned, would be widespread confusion and mistrust of the new technologies, job loss, social disruption, and alienation.

The recommendations and insights of Report 33 were based in large measure on a draft of a much larger work prepared by Arthur J. Cordell, an economist and science adviser to the committee. This work has been revised and updated and is being published here as a Science Council background study in the hope of making the ideas and information it contains available to a larger audience.

The Uneasy Eighties: The Transition to an Information Society is, in its author's words, "a series of connected essays" that examine some of the consequences for our working, public, and private lives of the widespread use of computers and related technologies. The study also includes an overview of recent developments in the important field of artificial intelligence, and reflects on some of the implications for society and human self-concept of an emerging machine intelligence.

As with all background studies published by the Science Council, this study represents the views of its author and not necessarily those of the Science Council.

James M. Gilmour
Director of Research
Science Council of Canada

Preface

In the past 20 years, developments in microelectronics and associated communications technologies — the new technologies — have transformed the computer. Today's computer is as different from the first computers as the Boeing 747 and Concorde SST are from the first aeroplane flown by the Wright brothers. What once cost millions of dollars and occupied a room the size of a garage now can be bought for a few cents and takes up less space than a dime.

Quantitative changes in computing technology have brought about a qualitative change in what computers are and what they can do. Tiny, reliable microcomputers are being used everywhere: in cars, homes, offices, factories — making decisions, controlling processes, storing and processing information. The technology is rapidly becoming as widespread, important, and socially transformative as electricity or the internal combustion engine.

Just as electricity and the internal combustion engine formed the basis for 20th century industrial society, so the new technologies are leading to the development of a society based on the rapid and inexpensive storage, retrieval, processing, and distribution of information. Western industrialized nations are shifting from economies based on the production of goods to economies based on the creation, management, and distribution of information and information-related services at an unprecedented rate. By some estimates the knowledge sector employed 40 per cent of the American workforce and generated 30 per cent of that country's gross national product in 1962. By 1977 the proportion of the GNP generated by information-related activities had risen to more than 50 per cent.[1]

As with many new technologies, the advent of computers was marked by much consideration and discussion of the technology — of what it was and how it worked. Thus, much of the early literature on microelectronics consisted of complex discussions of silicon chips and of how many components could be placed on a silicon chip now and in the future. Other articles or books dwelt heavily on computer languages, beginning with machine language and ending up with the highest level language in use at the time the article was written.

This study takes a different approach. It will deal more with what the technology can do for society and to society than with the technology itself. In the view of this writer it is time to move from describing the technical aspects of the new information technologies to learning how they can work for Canada and to assessing the magnitude of social, political, and economic change that can be expected.

The Uneasy Eighties is a series of connected essays. Chapter 1 provides a brief introduction to the technologies used in processing, storing, and transmitting information, which together constitute the infrastructure of an information society. Chapter 2 examines the impact of microelectronics on the range of goods and services produced in our society and the ways in which we produce them. The transition to an information economy is likely to have far-reaching effects on the quality, quantity, and type of work people do and on the relationship between work and income. Some of these issues are explored in chapters 3 and 4. The following three chapters are devoted to the complex question of privacy and the dangers posed to it by the proliferation of easily accessible information. Chapter 8 summarizes the development, potential, and implications of an emerging machine intelligence.

From time to time the technology will be discussed simply because this study could not be written without reference to certain key developments. However, the intent is to keep the language, style, and substance appropriate for a broad readership and to engage the reader's interest about a range of technological developments that will profoundly alter Canadian society.

Arthur J. Cordell
February 1985

Acknowledgements

The author owes much to the guidance and support of the members of the Science Council's committee on computers and communication. The chairman of that committee, Mr Ran Ide, was especially helpful in reading and rereading various drafts of this report. A special thank you goes to the library staff at the Science Council, who provided swift and reliable research assistance, and to all the paid and unpaid consultants, advisers, and friends in the network who provided valuable insights and guidance.

Chapter 1

The Information Infrastructure

Any new technology, if it is to become widespread, requires the development of a physical base or infrastructure. For example, in the evolution of industrial society, which was centred on the creation and marketing of industrial commodities, the necessary infrastructure included an easily and widely accessible network of roads, railways, and waterways, and the development of appropriate vehicles. It also involved the development of ways of producing and distributing various sources of energy to power both production and transportation.

Likewise, the evolution of an information society centred on the manipulation, packaging, and distribution of information is being made possible by developments in transmission and carrier technologies. Advances in these areas, combined with the extraordinary growth of computing technology in recent years, are rapidly forming an infrastructure for the information society.

The Computer

At the heart of the information infrastructure is the computer, a perfectly general-purpose machine that can be used to calculate a payroll, control the temperature of a house, play Star Wars, or process memoranda. New uses for computers are being found almost daily as developments in microelectronics lead to rapidly declining computing costs and smaller, more portable machines.

A computer has three basic parts: a central processing unit (CPU), a memory, and input/output devices for interacting with the outside world. The CPU carries out the work of the computer using instructions (programs) and data stored in its memory. The basic building block of the computer's CPU and memory is the logic gate.

Thirty-five to 40 years ago, logic gates were made from bulky vacuum tubes, and the CPU was the size of a garage. Later, as transistors replaced vacuum tubes, the CPU shrank to the size of a small pick-up truck. Each logic gate was formed on a single chip of silicon compound, about the size of a fingernail. By the 1960s improved manufacturing processes had provided the precision needed to place two or more logic gates on one chip. Today it is possible to put up to a million logic gates on a chip. When an entire CPU is placed on a single chip, it is known as a micro-central-processor, or microprocessor for short.

In three decades microelectronics has transformed the million-dollar CPU of the 1950s into a device costing $10 to $100. Costs per logic gate are currently falling at about 40 per cent per year. The computer's energy consumption and size are plummeting while reliability is skyrocketing.

Transmission and Carrier Technologies

Along with the decreased costs of computing power have come dramatic developments in the transmission and carrier technologies that will make up the roads and highways of the information society. These technologies (telephony, satellites, fibre optics, coaxial cable) are rapidly being upgraded, and improved ways are now being found to interconnect them. Eventually, networks comprising all these technologies will be developed to provide inexpensive and reliable national and international movement of information of all kinds.

The Telephone System

Since the invention of the telephone in 1876, telephone conversations have been transmitted in analog form. The amplitude of the electric current in the copper telephone line is directly proportional to the air pressure at the speaker's lips. Now analog transmission is being replaced by digital transmission. In digital transmission, the strength of the air pressure is automatically measured several thousand times per second and represented as a binary number, that is, a number made up of 1s and 0s only. The resulting string of 1s and 0s (or bits) is transmitted to the receiver where it is converted back to speech. Digital transmission also has a higher transmission capacity and quality than does analog transmission. However, its most significant asset is its compatibility with computing technology — both deal with information as bits. Thus a telephone network that speaks the binary language of computers can be used to interconnect geographically separate computers easily and elegantly into distributed computing networks. At the same time, computers can be used to process, store, and switch the telephone network's signals. Terrestrial analog microwave, the backbone of the North American long-distance telephone network since the early 1950s, is now being upgraded using digital transmission techniques. Computer technology and telephony are converging to provide greater versatility and universality for both.

Communications Satellites

Communications satellites, which can transmit and receive huge volumes of information over large areas of the earth, have greatly expanded the capacity of the telecommunications network. It is estimated that four appropriately designed satellites could handle all the long-distance telephone and data traffic of the United States.

Satellites will play an increasingly important role in communications as their launch costs and the costs of the earth-based receivers (dishes) continue to decrease. Reusable launch vehicles will contribute to declining launch costs, while the increased transmission range and power of satellites enable receivers to be smaller and simpler, and thus less expensive and easier to install. Estimates are that receiver dishes will soon be priced as low as $300 and will be less than one metre across. As receiving dishes become effective in receiving broadcasts even when placed in the attic or behind the window of a house or office, one can only expect their popularity to increase and government control over their use to diminish.

Fibre Optics

Since the beginning of long-distance communications, the problem has always been how to allocate finite amounts of information-carrying media among competing users. For example, over the years and with successive international conferences, practically all the limited radio frequency spectrum has been allocated to various broadcasters in different countries. Similar congestion is faced in telecommunications as the finite information-carrying capacity of copper telephone lines limits telephone company services to voice or low-speed data. Now it appears possible to reduce, if not eliminate, the problem of limited bandwidth by using light waves to carry information.

Light energy travels in a waveform, like radio waves and microwaves. Modulating or varying the amplitude of the light wave enables it to carry information in much the same way as analog radio waves and microwaves. However, the higher bandwidth of light waves allows them to carry much more information. Theoretically, a single light wave could accommodate every telephone message, radio broadcast, and television program in North America simultaneously.

Until recently, it was not possible to exploit the wide bandwidth of light. This was because there was no way to transmit light waves except through the atmosphere, where they are broken up and absorbed by smog, rain, snow, and fog. However, in the 1960s, a technology was developed that allowed light to be transmitted in the protected environment of a glass fibre or filament.

Fibre optic technology is highly suited to the digital transmission of voice, video, and data. The combination of digital technology and the high bandwidth of light, which allows extremely high digital pulse rates, gives fibre a vast information-carrying capacity. By some estimates, 10 000 simultaneous telephone conversations can be carried through a single pair of optical fibres. Twelve optical fibres in a cable with the diameter of a pencil could provide the capacity for more than 200 television channels, many with two-way capability from the home. Such a cable could also serve all the normal telephone needs, as well as all the foreseeable data communications needs, of the household of the future.

Because optical fibres can do so much in so little space, they are being installed in high-traffic telephone links. According to recent figures, North Americans make over 600 million local telephone calls each day – and this number is growing. Instead of increasing information-carrying capacity by tearing up streets to install more bulky copper cable, slender optical fibre cables can easily be pulled alongside existing copper cables or sandwiched among gas, sewer, and water lines in urban areas. These cables of glass can considerably expand capacity without extensive and expensive alterations to underground passageways.

Fibre optics is developing rapidly, with experiments under way in Manitoba, full-scale implementation of the largest fibre optic system in the world in Saskatchewan, and multipurpose experiments in Japan. In Japan, a computer and a transmission centre have been linked to 5000 homes by optical fibre. This system allows for a wide range of one-way and two-way services, including commercial radio and television, stock market quotations and weather reports, train and airline timetables, computer-aided learning, and interactive video networking.

Coaxial Cable

Communications satellites and fibre optics are among the most recent contributors to the emerging information infrastructure. However, coaxial copper cable, which has been in use for many years, also has considerable information-carrying capacity and can play a potentially important role in the information infrastructure.

Cable television in Canada began inauspiciously in Nicolet, Quebec, in 1950. The first systems were established in towns and villages where off-the-air television signals were poorly received. Early systems were limited in capacity to six channels, and 12 channels was the technological limit achieved in the 1950s. During the early years, Community Antenna Television (CATV) was strictly a redistribution service limited to television broadcasts, with little or no program origination. Cable systems were one-way distribution links that nonselectively delivered all program material to each subscribing household.

Today, cable television has become primarily an urban phenomenon, with penetration rates of 80 per cent to 90 per cent in some metropolitan areas. Many cable systems have increased their capacity to over 20 channels and, through microwave, some systems are distributing signals originating hundreds of miles away. In addition, nearly all of the larger cable systems now originate some programming and reserve community channels dedicated to that purpose. Cable systems frequently offer nonprogram information services (weather reports, stock market information, news, airport arrivals) and applications of two-way systems are well under way.

For many readers, the reference to interactive services may trigger memories of discussions about the "wired society" during the late 1960s and early 1970s. The technical feasibility of an interactive coaxial cable network offering a wide range of services, from teleshopping to information retrieval to teleconferencing, was at that time considered to be a likely development within the decade.

Although some experimental systems were offered on a very limited basis, the widespread development of an interactive cable system did not take place, as many experts thought it would, during the 1970s. A number of important technological breakthroughs were made in the cable industry, but interactive cable was either not available then, or, where available, was prohibitively expensive for most potential users. The costs of interactive cable technology did not begin to decline substantially until the latter part of the decade, owing largely to the cheap and efficient production of computer chips and, in particular, to the development of the microprocessor.

Although there was much talk in the 1970s of using an electronic highway for interactive services, there was little understanding of the limitations of the existing infrastructure of telephone and cable television networks. The telephone network (which allows transmission in two directions and serves close to 90 per cent of Canada's population) could not be used for the new interactive services because of its limited bandwidth. The telephone network, designed to handle voice communication through analog signals, did not have the broadband capability to transmit video signals as well. Even when converted to digital transmission, the local copper telephone lines leading to homes do not have sufficient bandwidth for video. These local lines, in contrast to the high-capacity intra- and intercity copper cables, can only carry up to 64 000 bits per second. High-fidelity music needs at least 400 000 bits per second, and colour television needs a channel capacity of 90 million bits per second.[1] The coaxial cable television system, which does have sufficient bandwidth to handle video and voice, could not be used for interactive services because it allowed transmission in only one direction.

Now, however, developments in microelectronics are enabling both the cable system and the telephone system to be upgraded to provide increased services to the home and office. For example, interactive services are being offered to Canadians over their cable systems. These nonprogramming services include fire and burglar alarms, panic buttons for police and medical emergencies, utility monitoring, and meter reading.

With these types of interactive service, a computer at the cable company's central office periodically sends a message or interrogating signal to the cable subscriber's home. A microprocessor in the subscriber's home reports on any changes that it is programmed to monitor by sending a digitally encoded message through the coaxial cable back to the central computer.

This kind of interactivity is relatively easy to install in most cable systems. More sophisticated designs, however, are being used for electronic polling, teleshopping, computer games, and other services that can now be delivered on a fully interactive cable system.

The well-known Qube system[2] in Columbus, Ohio, has its Canadian counterpart in a Canadian Cablesystems operation in London, Ontario. Both systems allow the viewer to "talk back" to the television set. By pushing the appropriate button on an electronic keypad, the viewer can signify agreement or disagreement with a question or issue posed by someone in the television studio; pleasure or displeasure with a performer on a community program; understanding of a question asked or a point discussed in an educational program; and interest in buying an advertised product. The system also allows for televoting or electronic polling.

For teleshopping and televoting, the conversion to an interactive cable system is relatively simple, since the amount of information sent back and forth is small. Because only simple responses, such as yes or no or a credit card number, are transmitted by the subscriber, the amount of information flowing upstream to the central computer represents a relatively small number of digital bits. Greater amounts of information flow downstream to the subscriber's home.

These services make use of the extensive capacity of the cable system, which is still a centralized (point-to-mass) distribution system modified to allow limited digital feedback to the central point. However, a more difficult and costly technical conversion of the existing cable network is required to offer more complex services such as electronic mail and messaging, teleshopping, and electronic banking. These services require considerable modifications to allow a greater flow of information back to the central computer. Of greater importance, however, is the fact that the cable network must be transformed from the current centralized distribution network to a decentralized (point-to-point) communication system. In essence, it must be given the switching capability of the telephone network.

Canada adopted coaxial cable long before the United States did. Thus the Canadian system is of the earlier type described above — a point-to-mass or broadcast system. In contrast, most of the newer systems being installed in American cities are second-generation systems with switching capability built in at the outset. A costly retrofit will be needed to make the Canadian system more interactive.

New Products and Services

Networks of various types capable of delivering large amounts of information are being constructed. Whether and to what extent one form will triumph over the other or whether compatibility can be developed remains to be seen. Whatever the carrier adopted (coaxial cable, optical fibre, radio, or microwave) and whether the switching system is based on the telephone company's existing system, a hybrid development (cable and telephone company), or something entirely new, it is becoming clearer with each technical advance and commercial announcement that two-way broadband information services will become a ubiquitous feature in homes, offices, factories, and stores throughout Canada.

Two-way information services already exist in the public and private sector. Many offices are adopting intracorporate networks and closed user-group systems. The trade journals contain announcements of local area networks based on one system or the other. The intent, in the office, is to allow the many different office machines to communicate with each other and with the electronic filing-cabinet of the modern office — the database.

The telephone terminals of the information society are, in effect, personal computers; sales of these instruments have soared beyond the predictions made only three or four years ago. Computers for home and office use have also increased tremendously in processing capacity and memory. Teletex and videotex form part of the mix of technologies, along with an intelligent terminal that allows easy access to and interaction with the information infrastructure. Although the use of many brands and many different types of software has created problems of incompatibility between machines and networks, there is little doubt that a technological infrastructure able to carry information services of all kinds at low cost is rapidly emerging.

The technologies are also merging to produce services such as electronic messaging with stored, digitally encoded voice messages. Such hybrid services, part communications, part computing, make nonsense of the efforts by government to treat the telecommunications industry and the computing industry as separate entities. Not only the technologies but also the industries themselves are merging, served by existing telecommunications and computer companies.

Meanwhile, new firms are being created, and existing firms are rapidly changing their corporate game plans.

Some of the more conspicuous providers of the new communications services in North America are: American Satellite, which provides voice, image, and data communications via satellite; Comshare, which supplies computer services, telephone systems, and data communications; Graphic Scanning, which operates a data communications network in addition to international telex and radio paging services; and Microwave Communications, Inc. (MCI), which offers long-distance telephone service between more than 100 United States cities. The list could go on and on and could also include companies such as International Telephone and Telegraph (ITT) Communications, Mitel, Northern Telecom, Western Union, Tymshare, and Satellite Business Systems (the consortium of International Business Machines (IBM), Aetna Insurance, and Communications Satellite Corporation). The giant American Telegraph and Telephone (AT&T) is moving quickly to make its presence felt in this fast-moving market with its Advanced Communications Service, designed to transmit data and allow technically incompatible computers to communicate with each other. Canada's Northern Telecom is already marketing a similar system under the OPEN World trade name.

The Creation of an Information System: An Analogy

In some ways the information society today is in the same stage of development as was the emerging automobile age in the year 1910 or 1915. A horseless carriage had been developed, but an infrastructure still had to be created and knitted together to provide an overall system. The evolution of the automobile from an interesting novelty into a major practical technology system required the creation of a reliable all-weather vehicle, the development of the gasoline pump and of a network of gasoline stations to power the vehicles, the building of durable roads to carry the traffic, and the creation of a complex set of standards and controls, including road signs, traffic lights, and appropriate legislation. All this took many years to put in place. For example, the first service station was opened in 1908, but the first metered electric gasoline pump was only introduced 28 years later in 1936. The limited-access highway, now an integral part of the automobile system, was not introduced in Canada until 1939. Traffic lights appeared in 1925.

As time went by, more and more of Canadian society was affected and changed by the automobile. The way in which cities developed and how and where people shopped, lived, and worked changed in profound ways. For example, the first climate-controlled shopping centre specifically designed for the shopper who arrives by automobile was opened in Canada in 1950. Today there are over 1800 such shopping centres in Canada. The shopping centre has also transformed the downtown area of most Canadian cities and become a local downtown region, a community meeting and activities place, a recreational area, and a place for people to meet when away from home.

The comparison between the development of the automotive culture in Canada and the emergence of an information society contains many parallels. Many apparently unconnected developments can, in retrospect, be seen as part of a larger pattern. As with the microcomputer industry today, many firms were started; some were successful, others went bankrupt or were acquired by their stronger competitors. At one time over 90 automobile manufacturers were active in Canada. None has survived except as part of large multinational companies.

The early automobiles were expensive and beyond the reach of most people. As the production techniques advanced, prices fell and the automobile became a mass-market item. Not only did it become more affordable, it also became easier to use. The average user no longer had to know how it worked, only that it did work. The technology had become "transparent." Automatic transmission, power-assisted steering and so forth took much of the work out of driving, while the repair of technical problems could be left to specialists.

Similar processes surrounded the emergence of the computer. With the decreasing cost of the technology, the computing experience has become less extraordinary, while the technology that accomplishes the user's ends is becoming increasingly transparent. The end point of the widespread use of microelectronics will be to allow computer users to achieve their aims without having to learn computer language or to know anything at all about the technology itself. The average user will give little or no thought to the technology except that it works and is affordable, reliable, and easy to use.

The excitement generated by the rapidly developing information technologies parallels the excitement that surrounded early developments in the automobile. The difference is that today people are consciously attempting to understand the system while it is being implemented. The present confusion will, in a decade or so, give way to order and many will wonder why there was so much concern over compatibility, standards, systems, and networks.

With the exhilaration of new technologies comes a certain uneasiness as long-established ways of doing things change. Patterns of work, leisure, education, and entertainment change rapidly, and the neat compartmentalization that characterizes these activities blurs so that old definitions no longer make sense either for individuals or for decision makers in governments and industry. Well-known firms and industries are transformed or go into serious, perhaps terminal, decline. New firms and industries lead to new occupations, and young people confront the dilemma of making life-long occupational choices in the face of an uncertain future. It is important to examine the costs as well as the benefits of the new technology.

Chapter 2

Products and Processes

Problems and Opportunities

Information technologies affect traditional factory and office settings by eliminating some jobs and creating others. The introduction of new machines speeds up operations and increases the range of services that can be delivered to clients. To use an analogy: a bulldozer can not only do the work of 30 people using picks and shovels, but it can also perform new tasks that previously could not have been imagined. It also creates whole new classes of employment: bulldozer operators, maintenance workers, producers of machines, and so forth.

The use of microelectronics has many other benefits for society. On the factory floor, manufacturing quality can be increased by closer monitoring, using microelectronic technology. Fewer flawed product components result in greater savings for the firm and for society because of the increase in productivity. As more intelligence is built into machines, less training is needed for new workers. In industries with a high worker turnover this can be very important. Other factory-related savings include the use of computerized machine tools that allow for greater precision. A more precise job leads to less wastage and increased productivity.

Examples could be drawn from all industries of how information technologies will redefine the workplace. The key issue is change.

The industrialized nations have become acutely self-conscious, keeping one eye constantly on the various indicators of wellbeing. Data relating to gross national product, employment, interest rates, plant closings, stock markets (Toronto, New York, Tokyo), the prices of gold and silver, currency values, and mortgage rates are part of daily life thanks to radio, television, newspapers, and coffee-break conversations with colleagues. We are like people compelled to take their temperature and blood pressure 10 times a day. Change by itself is a fact of life, but the changes related to microelectronic technologies are being reported in a way that increases general levels of unease, fear, suspicion, and overall dread of the future.

Industrialists are aware of the need to modernize ("innovate or die") in order to remain internationally competitive. At the same time, there is a growing realization that the new technologies bring change and job loss. Notes George Wedell, head of the community employment projects division of the European Economic Community Commission:

> The pressure to go one better in technological development almost inevitably increases the employment problem. The labour factor be-

> comes a major variable because of automation at the very time when political pressure [is for full employment]. Technologically induced unemployment, which is of course nothing new, has now reached dimensions exceeding the absorptive capacity of the labour market and of its management institutions as they at present exist in most member states of the Community.[1]

The extent of change in labour markets is so profound that Wedell urges that employment policies anticipate technological change rather than react to such change.

> Both the extent of the interaction of social and economic issues and the timescale needed for the modification of policies are crucial factors, which render it essential for employment policy to be an agent rather than a consequence of economic policy decisions. Now that is a total reversal. What is at stake is the creation of a new pattern of life brought about by the third industrial revolution which was predicted by Professor Wiener at MIT back in the 1950s — and we never took it seriously. We need a new pattern of life brought about by this third industrial revolution and if by means of a dynamic employment policy this new pattern can be identified and introduced, I think the change will create the climate in which the necessary economic changes also become possible. What I mean is that it will reduce the element of fear — fear in all of us, and a very proper fear — about our existence, our jobs, our families: a fear which at the moment is ossifying large sections of our society.[2]

Products and Production Processes Are Changing

The new technologies change the nature of traditional manufacturing processes in two basic ways: by simplifying products and by automating the production process. In the first case, products are simplified by replacing parts that carry out logical operations — springs, levers, stepping motors, and gears — by microelectronic circuitry. This results in a product that has fewer parts and requires less labour to produce. The substitution of electronic parts for mechanical ones often leads to a dramatic shift in labour from the factory that assembles a product to the integrated circuit plant that produces the chip that replaces a vast number of wheels and pulleys. In the second case, the production process is itself automated through the application of computer-aided design and computer-aided manufacturing (CAD/CAM), robots, computer-controlled machine tools, and automated techniques for handling materials.[3]

The type of production that simplifies the product makes it less expensive to produce and sell. Industries that fail to adopt the new technologies will be greatly affected. The outstanding and most visible example is the Swiss watch industry. Employment in the Swiss watch and clock-making industry fell by 46 000 in the mid-1970s, and employment in the watch industry in West Germany is estimated to have fallen by 40 per cent at the same time.

Over the last few years, watches, calculators, television sets, cash registers, and telecommunications equipment have all been radically simplified. The major Japanese manufacturers of television sets have been able to cut their staffs by 50 per cent and increase production by 25 per cent. This was achieved by the substitution of microelectronics for traditional circuit boards. Not only did this changeover reduce the labour required to assemble television sets, it also reduced parts manufacture, facilitated quality control, and cut down on maintenance.

This trend is not restricted to electronics companies. It cuts across the broad spectrum of manufacturing.

- An electronic watch requires the assembly of only five components as compared to some 1000 assembly operations for a mechanical watch.
- In the past, the production of an electromechanical teleprinter required more than 75 hours, whereas an electronic teleprinter takes only 17 hours to assemble. One microprocessor can replace over 900 mechanical parts.
- Over nine hours were needed to assemble a mechanical calculator; a printing electronic calculator requires less than one hour.
- In the manufacture of sewing machines one microprocessor has replaced 350 mechanical parts.

In terms of value added, the electronic components become a much more important part of the product and a large part of the value is therefore transferred from the equipment manufacturer to the component manufacturer or semiconductor manufacturer.

The traditional structure of the production process is typically characterized by a number of phases — the manufacture of materials into components, the assembly of components into subsystems, the assembly of subsystems into products, testing, and sales. In general, the later phases are the more labour-intensive.

The new structure that emerges using microelectronics is one in which the bulk of subsystem and component assembly work is replaced by component manufacturing, and much of the final stage of product assembly becomes the assembly of components. Component manufacture itself is not a labour-intensive activity. It appears that many of those industries in which high growth can be expected over the next decade — electronics, telecommunications, consumer goods, precision instruments — are precisely the ones that will be most affected by the process of simplification.[4]

The factory of the future will consist of systems for monitoring and controlling the production process as a whole, robots and computer-controlled machine tools to perform the necessary physical operations, and some form of materials handling equipment to control inventories of new materials and finished products.

Although computers have been used in the control of industrial processes for some time, previous attempts to control an entire plant were unsuccessful. The reason for this is that the early efforts were based on the concept of centralized control. Early computers, however, were seriously limited in speed, in memory capacity, and above all in the sophistication of their programs.[5]

Today's approach to the control of a complex industrial plant is based on the concepts of decentralized control, distributed data acquisition, and distributed information processing or "distributed intelligence." In such control systems, local problems are solved at a local level and higher problems are solved at a higher level. These systems can be implemented with a hierarchy of computers, each performing tasks appropriate to its position in the hierarchy. This approach allows for design flexibility, as well as improved reliability and performance, and appears to make possible the elusive goal of fully integrated plant control.

Computers Change Design and Manufacturing

Total control by distributed intelligence is the most sophisticated example of a more general set of technologies usually referred to as computer-aided manufacture or CAM technologies. These include computer-based scheduling systems, inventory control systems, and partial process control systems. These technologies have the collective potential to increase the overall productivity of factories by reducing manpower requirements, making the best use of raw materials, decreasing levels of stock on hand, and improving the relationships among the different processes and activities.[6]

Microelectronics allows automation to start at the level of design. When computers were first used in Canada in the early 1950s, the emphasis was on engineering computation. In the intervening 30 years, the capabilities of electronic computing power have evolved from computing to logical ability, memory, and graphic display and output. The advent of graphic displays has automated the task of drafting as well as engineering. With this enlargement in scope, the name of the activity has been appropriately changed from engineering computation to computer-aided design, abbreviated as CAD.

Computer-aided design puts into the computer all the tools normally employed in drafting, such as triangles, pencils, and compasses. CAD not only speeds up the slow and laborious work of drafting, but also enables the designer to study various aspects of an object or assemblage by rotating it on the computer screen, separating it into segments, or enlarging or shrinking details. What is more, the designer can analyse and test the objects designed immediately, subjecting them to electronically simulated temperature changes, mechanical stresses, and other conditions that might occur in real life. This on-screen testing can save the enormous amount of time and expense involved in building prototypes that must be tested, modified, and retested.

When CAD is closely linked to CAM, the on-screen designing and testing of a product can generate a program of computer instructions for its manufacture and for the tools, dies, and moulds used in manufacturing it. This CAD/CAM link greatly shortens the time between design and production. It is less expensive to develop new models, make midstream design changes, customize products, or set up short production runs.[7]

The continued improvement in the performance/cost ratio of available computers makes applications like CAD/CAM possible. Comparatively inexpensive computing power and data storage devices, coupled with an expanding awareness of computers, has made CAD/CAM a powerful new tool for the Canadian manufacturing sector.

The productivity gains from CAD/CAM technology are enormous. One automotive engineering executive noted that, with computer-aided design,

> We do the design work on graphics and look at the results on graphics — all totally devoid of real parts to test. We can go through the whole process and have a good idea what the part is going to weigh, how strong it will be, how stiff, how well it will perform. We fix parts before the car is built.[8]

Factory automation increases productivity and also changes the nature of the production process itself. The automated automobile factories of North America are twice as efficient as their less automated counterparts in the United Kingdom but half as efficient as the most automated automobile factories in Japan (which use CAD/CAM techniques and robotics). Thus, in the United Kingdom, the auto industry produces about 15 to 17 cars per person-year; Japan's automakers produce almost 70 cars per person-year.

The greatest benefits occur in small production runs or in batch production. CAD/CAM and robotics allow small plants to achieve the low-cost production that is usually associated with large plants built for world markets. The term that best describes the new approach to manufacturing is flexible manufacturing systems (FMS). The potential of FMS lie in their capacity to manufacture goods cheaply in small volumes. Different products can be made by the same machines merely by changing a program. The assembly-line approach, best demonstrated in the conventional automobile plant, is inflexible. To reduce costs, high-volume output is necessary. But 75 per cent of all manufactured products are produced in batches of 50 or less. General Electric, for example, uses FMS to make 2000 different versions of its basic electric meter at its Somersworth, New Hampshire, plant with a total output of over one million meters per year.[9]

A related development is the use of the technique known as group technologies. This is the process by which the common features of parts of products are classified, coded, and stored in computer memories for later recall and production. This approach is especially powerful in batch production in which changeovers from one operation to another are a constant feature of the production process. By recycling previous solutions for producing particular parts of products (that is, by grouping the technologies), savings can be gained throughout all manufacturing operations, including those characterized by the batch mode of operation.

The labour savings made possible by group technologies are impressive. Studies carried out in various companies show that only 20 per cent of parts initially thought to require new designs actually need them; 40 per cent could be built from an existing design and the remaining 40 per cent of new parts could be created by modifying an existing design.[10]

Robots and the Automated Factory

Another key element in the automation of the production process is the use of robots. A robot is a programmable, multifunction manipulator designed to move materials, parts, tools, or specialized devices through predetermined motions for the performance of a variety of tasks in the same way as a human hand or arm. It consists of three elements: the mechanical structure (including the artificial wrist and gripper), the power unit (hydraulic, pneumatic, or electrical), and the control system (usually minicomputers or microprocessors). However, the essential characteristic of a robot is that it can be programmed, which means that it can be taught new tasks.

Robots have been used in industry since the early 1960s. The first models were big machines designed mainly for tedious and hazardous jobs. Today's robots are small and versatile and can be programmed to do a number of tasks. The new robots with microelectronic circuitry are especially suited for manufacturing operations and are an integral part of flexible manufacturing systems.

Robots cost from $10 000 to $120 000 and auxiliary equipment can double the installed cost. The expense of maintaining a robot is about $5 per hour. Contrary to popular notions, the higher productivity of the robot has little to do with higher speed; they are generally designed to work at a human tempo so that they will mesh with the existing factory operation. The productivity increase comes from the robot's ability to work around the clock more consistently and more precisely than a person.

It should be noted that another powerful incentive for using machines instead of people arises from the increasing number of lawsuits brought by workers who have either handled or come into contact with hazardous materials. Higher standards designed to protect workers in hazardous areas increase the costs of labour as well. The costs of protection are changing the 3:1 ratio (labour at $15 per hour versus robots at $5 per hour) to a ratio of 4:1 or more. There is no need to provide physical protection for robots or to worry about lawsuits arising 10 or 20 years later when chemicals or other substances considered safe today are found to be dangerous.

While robots are currently being used to increase productivity in existing plants, the nature of the technology associated with the new robots (which are reprogrammable and multifunctional) is leading to a change in the whole production process and to the era of the fully automated factory. With CAD/CAM technology the plant will be designed from the ground up to exploit the full capabilities of robotics (speed, versatility, and so forth) rather than to make the robots fit into existing methods of production.

The demand for robots is a function of a desire to reduce costs and ensure an adequate supply of labour. The era of productivity improvements based on the constant growth of the volume of production appears to be over, and so increases in productivity are linked closely to the capital and technology invested in the production process.

This reorganization of the production processes creates a new type of value added in the information that microelectronics generates as a byproduct of the many automated processes. Production can be integrated with other activities such as automatic design, automation of order handling, materials handling, packaging, and warehousing — all through the integration of CAD/CAM technologies.

The gains from robotics and CAD/CAM technologies are impressive. The Toyota plant in Japan employs the same number of people as it did five years ago, but has increased its annual production from two million vehicles to three million. Mitsubishi, another car company, produces seven times as many cars as it did in 1970 — with a work force only 15 per cent larger.[11]

The trend toward robotics is so pronounced in Japan that Fujitsu Fanuc (one of Japan's largest machinery firms) has opened a plant that uses robots to make robots. The $100 million plant, built in 1982 near Tokyo, employs 150 people and 30 robots; every month it produces 500 industrial machines and 350 new robots.

A prototype machine tool factory will open in 1984, consisting of 65 computer-controlled machine tools and 34 robots linked by a fibre optic cable with a computerized design centre at headquarters. The Yamazaki factory at Nagoya, Japan, will have 215 workers in an operation that would have needed 2500 workers if it had been designed more conventionally. Its flexible plan can operate at full capacity (turning out about $230 million worth of products per year) or can be cut back (to $80 million per year) without having to lay off workers.[12]

Japan currently produces over 150 different models of robots. These range from specialized models that unload injection-moulded products, stack heavy loads, or perform semiconductor chip bonding processes, to general-purpose robots that palletize, assemble, weld, and paint with equal competence. The leading Japanese tool builder, Yamazaki, produces a sophisticated machine tool or machining centre every 40 minutes. The machining centres run unattended all night with the lights off, building still more machining centres.

The trend toward unmanned production lines is leading to a third shift for production that needs no human input at all — what West German workers call *die Geisterschicht,* or the ghost shift. Many factory workers who formerly worked all night will now be able to work during the day, more in tune with the rhythm of society.

New developments in robotics include robot vision. In France, the automaker Renault has a robot with a television camera acting as an eye. This robot can identify each of 200 parts presented to it at random on a conveyor. There are an estimated 800 machine-vision systems installed in the United States, and sales are expected to double every two years.[13] Many machine-vision systems are being installed as stand-alone systems (not associated with a robot) to measure, count, or check for quality; the idea here is to replace the human eye with systems that are faster, more accurate, and less likely to make mistakes. Robots are also being developed that have a tactile sense and can determine whether a particular part is defective. In all, the development of microelectronics has allowed robots to be smaller, more versatile, more intelligent, and retrainable for various new tasks as the need arises.

Offices Are Being Automated

What has been sketched above for factories is also occurring in warehousing, distribution centres, and in the most complex area of all — the office. Office work is changing to an automated set of functions in which electronic products and sophisticated communications terminals replace electromechanical products. However, productivity is more difficult to measure in the office than in the factory.

Office routines are based on patterned human behaviour, but even with closely monitored studies of what is going on in the office environment, it is often unclear how a particular system operates. Most office tasks are less routine and more intangible than tasks carried out in a factory. In some cases, especially in the larger university, corporate, and government bureaucracies, it is often difficult to specify precisely what is being done, let alone measure it. As a consequence, it is hard to define what constitutes productivity in the case of some office activities or describe how — even in general terms — the productivity of these activities could be improved.[14] Nevertheless, even in these cases there is a clear trend toward automation.

Office automation will bring increased flexibility but it will also mean increased homogenization and use of systems. The desire to use the new equipment efficiently means, for some, that standardized procedures must be adopted. Numerous studies are under way in corporate and government bureaucracies to understand the aims and objectives of the office, what can be standardized, and how much routine can be imposed on managers and workers without lowering morale and efficiency. These studies show that parts of the modern office may come to resemble the factory.[15]

Spurred on by the promise of increased productivity and a desire to appear to be in tune with the new technology, governments and corporations are moving to incorporate information technologies to store, process, manipulate, and communicate information. The workstation is taking the place of the typewriter, copier, filing cabinet, and telephone as separate items. After buying into a data communications network, corporations find that teleconferencing can take place with little added cost. Satellite data systems often allow for video conferencing. Experiments and pilot projects are under way with portable terminals to allow some office workers to work at home.

Telecommuting or teleworking is expected to save energy, employ the handicapped, reduce the need for office space, and allow greater participation in the labour force for working mothers. By the mid-1990s, an estimated 15 per cent of the workforce may be telecommuting, that is, working away from a central office.[16]

Information technologies allow for increased speed and flexibility, reduce or eliminate the constraints of distance, and may lead to the transformation of the office from a place for workers to be from nine to five to a concept or an activity that can be accessed or activated from anywhere in the world at any time. The roles of managers and support staff will change. Employment will change both in numbers and job description.[17]

Thus the familiar typewriter, filing cabinet, telephone, and office copier will eventually merge into a single office communications and information processing network. At multipurpose, complex workstations, office workers (including managers and support staff) will be able to perform a wide range of functions including: recording notes and drawings, taking a letter, filing information, displaying a page from an electronic file. From these same workstations it will be possible to make a simple telephone call, leave a digitally encoded message, activate microelectronically controlled copiers, print forms or letters, and write or edit a report or memo. All workstations will be linked to computer databases, a duplicating and printing centre, and a communications centre, which will be the voice, video, and data gateway to other electronic offices in the building, across town, or around the world.[18]

Chapter 3

Work, Working, and Income

Fears and hopes associated with widespread automation have been with us since the early days of the industrial revolution. The Luddites, concerned with the loss of jobs to machines, have their present-day counterparts in those who fear the loss of jobs to fast, efficient computers. The early 1960s saw an automation scare that, in the United States at least, was calmed by the report of the United States National Commission on Technology, Automation and Economic Progress published in 1966. The report concluded that automation is not dramatically different from any other technological change that has been introduced since the start of the industrial revolution.[1]

The conclusions of the report, which adopted what is now referred to as the "business as usual" approach, were largely valid for the 1960s and 1970s; but the emergence of two new factors during the 1980s has altered the situation. First, economic growth in most western nations has become erratic and difficult to predict; it is no longer possible to rely on increased consumption to provide new employment opportunities for those displaced by new technology. Second, the main-frame computer era of the 1960s is over; silicon chip technology is diffusing at a rate estimated to be seven to 10 times faster than that of any previous technology.

In discussing how many jobs will be available in the future, distinctions must be made between the short, medium, and long term, and between structural unemployment and net unemployment. Structural unemployment results from change in one or more industrial subsectors; net unemployment refers to job loss throughout the entire economy as a result of automation. The consensus to date is that structural unemployment is definitely a feature of the 1980s; the opinion on net unemployment is divided, with the optimists in one camp saying that new technology creates new jobs by creating the conditions for economic growth, and the pessimists in the other camp saying that the new technology is like no other ever seen: it is labour saving, capital saving, and energy saving. Moreover, it is being introduced at a very rapid rate into economies that are plagued by inflation and stagnating rates of economic growth. Most commentators agree on one point, however: the short term will bring disorder, disruption, and uncertainty to labour markets.

Three years ago Gerald Regan, the former federal minister of labour, expressed his concern about the impact of microelectronics on employment in this way:

> The final verdict on the net employment effects has not been rendered yet, but it is clear that several industries will undergo serious adjustment difficulties. Our concern is heightened in light of an OECD survey which found that, even in the electronics industry, few of the major corporations are expected to increase employment over the next few years. If even these firms are not going to add jobs, we may well ask from where is employment growth in manufacturing to come.[2]

New Technology Increases Productivity: An Example from Telecommunications

New technology is being used to improve productivity in every labour-intensive sector of the economy. On the shop floor, in offices, in middle and senior management, computing power is substituting for human intelligence and computer memory is taking the place of paper records, files, and memos.

The use of word processors in place of typewriters increases the productivity of office workers by 30 per cent to 70 per cent. The use of electronics permits the use of fewer people. This fact is most clearly illustrated in telecommunications manufacturing and in the operation of the telephone system. In fact, the telephone system may be a model of how automation will be introduced throughout the service sector.

The introduction of the computer has vastly increased productivity and reduced employment in the telecommunications industry. At the same time as it threatens jobs, the computer speeds up the pace of work and results in much tighter supervision and a more controlled environment for switchboard operators.[3] Toll switchboards are now computerized, electronic switching is replacing electromechanical switching, and the digital switching centres require fewer people to install and maintain them. New computer-based systems have already reduced operator staffs by 22 per cent to 40 per cent (in Vancouver and New Westminster, British Columbia). The centralization made possible by these new systems has meant that towns like Cranbrook and Vernon in British Columbia or Pembroke, Ontario, and Ste-Agathe, Quebec, have no operators working in them at all. The implications of the small-town shutdowns are obvious. Most of the operators are women; job opportunities for women in those centres are limited, and transferring to the closest metropolitan centre is generally not possible because of family responsibilities.

Productivity in the telecommunications industry has been greatly enhanced by the Traffic Operator Position System, or TOPS. Using a keyboard and video display screen to replace the manual systems of the past, TOPS automates the timing, ticketing, and supervision of telephone calls. TOPS also gives the operator more details of each call.

Depending on the type of call, the video screen can show the number being called, the credit card or billing number, the applicable billing rate, the routing of the call, and the number of the hotel room or extension being charged — information that saves time and increases worker productivity.

If the goal of automation is to increase productivity, then our society has been extraordinarily successful in achieving its goal in the field of telecommunications. As Wassily Leontief, the Nobel prize winning economist notes,

> Thirty years ago, it took several thousand switchboard operators to handle one million long-distance telephone calls; 10 years later, it took several hundred operators; and now, with automatic switchboards, only a few dozen or so are required. The productivity of labour — that is, the number of calls completed per operator — is increasing by leaps and bounds; it will reach its highest level when only one operator remains, and become infinite on the day that operator is discharged.[4]

If the telephone system is considered as a paradigm for automation in other parts of the service sector, it is worth asking this question: By trying to achieve ever-increasing rates of productivity without regard for displaced and redundant workers and without regard for workers' incomes, will we, as a society, be creating more problems than we solve?

Information Technology May Affect Women More than Men

The increasing presence and permanence of women in the labour force is one of the most significant developments in Canadian society during the last 30 years. This trend is expected to continue as social conditions lead to an increase in the number of single parents, as economic realities necessitate the participation of both spouses in the workforce, and as changing life styles make paid employment almost as permanent a fixture in women's lives as it is in those of men. In 1953, the proportion of women in the labour force was 23 per cent; by 1979, it had more than doubled, to 49 per cent. During the 1970s alone, the number of women in the labour force rose by 62 per cent. In May 1980, 4.6 million Canadian women were either working or looking for work.

Most of the employment growth during the last 20 years has been concentrated in the service-producing, tertiary sector of the economy. During the 1970s alone, 85 per cent of the new jobs created (two million) were in this sector, which increased its share of employment from 30 per cent to 60 per cent of working Canadians. Not surprisingly, with the tertiary sector's boom corresponding to the period in which women's labour-force participation was rapidly escalating, women have become more concentrated in this than in any other sector. In May 1980, the service-producing industries accounted for 81 per cent of all women in the labour force.[5]

Because the service sector is a prime target for automation, it is likely to suffer severe job displacement and reduced employment prospects. Information technologies will be applied first in those areas characterized by routine or standardized behaviour. One such area is the clerical area. It also happens to be the area whose workforce is mainly female. Women, it seems, may be harder hit than men by the new technologies.

As well, the implementation of the new information technologies is widening the disparity between the clerical and the professional information-related occupations. Clerical workers generally have the fewest opportunities for educational leave and staff training. Women have particular problems upgrading their qualifications because of family considerations. In addition, women's recent entry into traditionally male occupations is relatively minor compared with their continuing strong concentration in the clerical occupations. Hence, more and more young women entering the labour market and older women returning to it could become structurally unemployed and suffer long periods without work.

Increased Productivity May Lead to a Smaller Bureaucracy

The effects of microelectronics and computers on municipal employment were studied in three major cities in Ontario.[6] Along with gains in productivity came substantial cost reductions for certain operations. In the automated departments, the number of employees first increased slightly, then levelled off and remained stable later despite sometimes quite substantial increases in workload. Displacement rather than unemployment was the rule for municipal employees in the departments that adopted the new technologies. Redundant jobs were usually eliminated by attrition or lateral transfer; overtime work, casual employment, and contracting out were reduced, but no outright firings were reported.

The effects of automation on workers' occupations and skills differed from department to department, according to the character of the new application and the way in which it was implemented. In financial operations, a pattern of middle-level job loss led to a widening of the gap between the diminishing number of lower-skilled clerical workers and the increasing number of highly skilled workers responsible for computing, accounting, and analysis.

In the years ahead, many more occupations associated with municipal governments will be transformed through closer contact with information technologies. Besides nearly all clerical and secretarial staff, workers in occupations such as building inspection, drafting, and fire protection are expected to become users as well as recipients of electronic information processing based on microelectronics and computer technology. Although there is little need to fear that these new applications, any more than the old applications, will directly result in the loss of large numbers of jobs in municipal administrations, the prospects of indirect job losses and of lack of future employment growth is another question entirely. There is almost universal agreement that without information technologies, municipal employment would have had to expand significantly over observed levels just to keep up with increasing demands.

Winners and Losers

Although many jobs will be lost with the introduction of the new technologies, many new jobs will be created. However, the new jobs that are being created cannot be staffed by the people who have been displaced. The skills needed for the new jobs are entirely different. For example, in a changeover to computer-based typesetting, the total number of jobs on one shift in a newspaper printing plant fell from 52 to 29. Five video display unit (VDU) operators replaced 12 typesetters; a further five VDU operators replaced 10 correcters, and seven people replaced 15 workers doing layout.[7] Typesetters, correcters, and layout people are highly skilled workers who earn reasonably good salaries; they were replaced by operators requiring only basic typing skills. A study by Mackintosh Consultants Limited of the United Kingdom and Pragnos, AG of Basle, Switzerland, predicts that information technologies in the 1980s in West Germany will result in the loss of 1.8 million jobs in the low-skill sectors and a gain of 1.9 million in the highly skilled occupations.[8]

Some observers have pointed to events now taking place in the New England states as an example of the transition that the entire industrialized world is, or will shortly be, experiencing. The area's aging industrial base had deteriorated to such a point that by 1975 its unemployment rate of 10.2 per cent was the highest of any region of the United States. But that year marked a turning point. Attracted in part by the proximity of distinguished universities, high-technology firms began flocking to the area. The new companies created a need for highly paid professional workers, such as management consultants, engineers, architects, and accountants. In turn, the presence of these professionals provided a boost to retailing and other services.

What happened to the workers in the older industries? Barry Bluestone, director of the Social Welfare Research Institute at Boston College, studied social-security data on the 674 000 workers who had been displaced from the region's old mills since 1958. He discovered that by 1975 only 20 000 millworkers were employed in high technology industries, while more than 100 000 went into the lower-paying trade and service jobs. In addition, says Bluestone, "a huge number" of the workers simply dropped out of the labour force or moved into jobs not covered by social security. One conclusion of the study was that "losing one's job as a result of deindustrialization tended to propel one downward in the industrial hierarchy, not upward."[9]

New job openings are occurring in all areas of computer design and application. The hardware area needs skilled people with electrical engineering backgrounds to design chips and their applications. The software area is open to those who understand control, production, and mechanical systems.[10] The demand for professionals ranges from data processors to those skilled in logic, systems, and software of all types. A review of the employment opportunities section in any major Canadian newspaper gives an idea of the types of new skills needed in an information society: electronic process engineers (to design chips); applications engineers (with a multidisciplinary background, usually gained from experience in an industrial setting); electronic test technicians (needed for final testing of products that incorporate microelectronic components); electronics maintenance and service technicians; hardware/software engineers (high-level applications demand individuals skilled in both hardware design and software); and control engineers (specialists in creating instrumentation that links with continuous process production applications).

New Technology Changes the Quality and Quantity of Work

The two profound changes in employment that are beginning to emerge are de-skilling and jobless growth. When more intelligence is built into a machine, an operator needs less skill to run it. Also, with the use of modular production techniques using integrated circuits, there is less need for the skilled maintenance person. When a part fails, a module is simply removed and replaced with another. Thus Western Electric estimates that there will be a 75 per cent reduction in the need for labour in maintenance, repairs, and installation work as a result of the introduction of electronic exchanges. The growth in the use of satellites for message switching in the 1980s will reduce the demand for maintenance services even further.[11]

The trend toward de-skilling leads to the inevitable creation of a bimodal distribution of skills in the labour force. Simply stated, the introduction of machine intelligence into the manufacturing and service sectors is leading to a division of workers into those who are highly skilled and those who are unskilled. This process eliminates the intermediate skills range that is vital for both actual and perceived upward mobility. This trend will not be restricted to unionized workers but will affect middle management as well. As one participant noted in a workshop convened by the Science Council,

> A Canadian local bank manager pointed out that his regional vice-president knows precisely the state of his branch, at any point during the day, by pressing the appropriate buttons. He can know the state of deposits in the bank, the state of withdrawals, the state of payments of loans, defaults on loans, everything that is put in the data banks, the bank's central place. So I asked the branch manager, "What is your role?" His response was "I'll be damned if I know."[12]

Information technology has the capacity to centralize information and change the focus of decision making. In this case the authority of the middle management person, the local branch manager, has been changed and substantially reduced by electronic data processing.

Consider by way of analogy the Boeing 747 aircraft. At one end of the multimillion dollar machine are the highly skilled pilot, copilot, and navigator; at the other end, in the cabin, are the flight attendants. One does not become a pilot by working for the same airline as a flight attendant; rather, one must drop out and, if possible, be retrained for the more skilled and highly paid job. In future, the skills profile of Canadian society will tend more and more to resemble the situation in the aircraft. There will be less and less demand for the semiskilled worker. Of special concern is that the polarizing of skills will limit the possibility of upward mobility. A real or perceived barrier to upward mobility could create new class divisions, conflicts, and tensions in the information society of the future.

The labour-saving impact of the new technologies will take some time to become fully apparent because most companies and government agencies are recording increases in output without having to hire more people. With jobless growth, the phased introduction of computer technology is allowing natural attrition to take care of redundancies in the labour force.

It is expected that as many as 45 million jobs in the United States will be affected by information technologies. One survey expects that before the year 2000 there will be "a radical restructuring of work, including a devaluation of current work skills and the creation of new areas at an ever-increasing rate. This will result in a fundamental change in most workplaces and an often painful adjustment for the workers involved." Citing a Carnegie-Mellon University study of robots, the survey notes that current robots could take over seven million factory jobs. The United Auto Workers expects its auto industry membership to drop from one million to 800 000 between 1978 and 1990, even assuming a 1.8 per cent annual increase in auto sales.[13]

Job loss from lay-offs during a downturn in the business cycle has a different psychological effect from job loss because of redundancy. In the first case, the cause of lay-offs is perceived to be an outside force that affects everyone in society — a force over which the worker has little or no control. In the case of redundancy, however, there is a feeling of being singled out for replacement, a feeling that the individual's contribution to the firm was negligible (since it could be replaced by a machine). The loss of self-esteem that follows the sudden realization that one's skills are no longer needed or wanted can be overwhelming and psychologically damaging.[14]

Reports from leading business journals indicate that even a return to economic boom will not affect the unemployment figures. The race to automation means that increased profits will be invested in new equipment rather than in hiring more people. A recent survey of 1000 European manufacturing companies by Management Centre Europe (MCE), a Brussels-based consulting group, found that even with normal growth rates, about 33 per cent of respondents would not hire new employees, and an additional 30 per cent said they would continue cutting employment wherever possible.[15]

Trends in automation combined with a permanent contraction in primary and fabricated metals, transportation equipment, nonelectrical machinery, and textiles indicate that nonskilled workers will be on the unemployment rolls for some time. In the United States, for example, industrial employment is down by more than three million from its peak in June 1979. The bulk of the lost job slots have been blue-collar positions: one in five factory jobs has been eliminated since mid-1979. According to *Fortune* magazine, many of these jobs are gone for good.

> The American economy faces a serious mismatch between skills and opportunities. Blue-collar employment will grow feebly in the period ahead, while the strongest call will be for labour to staff either low-paying service jobs or posts calling for specialized skills. The financing industry, for example, added more than 100 000 managerial jobs over the past 18 months, while it cut clerks and tellers. This reads like a recipe for structural unemployment.[16]

Outstanding Issues: Work and Income

The future of work and working in the evolving information society is subject to much debate. Some trends, outlined above, are clear; others are emerging. The new technologies will change the nature of work, the place of work, and the importance of work to society. With sophisticated communications technology the office, for many people, will gradually become more of a concept than a place to be from nine to five. Anywhere a person can have access to a telephone will be the "office" for that person. With portable intelligent terminals the individual can send memos or mail, receive messages, write and file reports at any time and from any one of the over 400 million telephones in the world. Working at home and teleconferencing will increase — especially as the cost of liquid fuels continues to increase. With an increase in energy costs and with decreased telecommunications costs there will be both a personal and corporate incentive to substitute communications for travel and commuting.

The impact of the new technologies on the amount of work that will be available is less clear. It appears that the long-term trend to shorter work weeks will be continued after a decade-long stall at 40 hours per week. There may be a movement to redistribute the available work among the remaining workers — to provide them with more pay and shorter work weeks. Increased productivity will bestow greater profits on industry while permitting a share of those profits to go to labour.

The notion of work itself may change. Over time, work has changed from a necessary activity that transformed resources into usable goods, to a mechanism for distributing income. Self-esteem, identity, and self-worth have meshed with the employment of the individual. If some of the forecasts prove correct, far less labour will be needed. Thus new forms of nonmarket employment programs will have to be undertaken. The guaranteed annual income, the nonmarket direct employment programs, and other innovative ways of distributing income will have to be studied and tried by enlightened governments. Whatever happens, it appears there will be significant numbers of people who will no longer depend on jobs for necessary income. How will the tendency to define people in terms of their work affect those who no longer "do" anything?

Do People Really Need to Work?

The people who see the long-term employment trend as positive are those who study the area of leisure. For them it is time to manage the transition to the postindustrial society. According to John Farina, a professor in the faculty of social work at Wilfrid Laurier University in Waterloo, Ontario, "Man invented machines so man would not have to work and we have succeeded to the point of one and a half million unemployed. But instead of cheering about it, we're in despair. To me that is sheer, raging idiocy." The problem, for Farina, is that "we are trying to cope with a post-industrial society on the basis of industrial society values and ethics and it just isn't working."[17]

It must be remembered that full employment is a political objective, and that nothing in economic theory states that all people who want to be employed must be employed. In fact, the notion that full employment is the norm is quite recent to industrialized societies. The British White Paper of 1945 proclaimed, for the first time in modern history, the government's responsibility to provide full employment in the postwar world. And in the United States, the Employment Act of 1946 committed the American government to the maintenance of "maximum" employment. These political ideals of the industrial age — in large part a reaction to the 1930s — may be outdated. Income, and not employment, will be the key issue for the 1980s and beyond.

A time of change brings with it many predictions: that economic growth is over; that if people have the vision and wit to take risks they can know a kind of prosperity that they never dared imagine. John Maynard Keynes addressed these issues in 1930 in the essay "Economic Possibilities For Our Grandchildren," which appeared in his *Essays in Persuasion*. His prognostications outline a situation very much like that being experienced today. The western world was in 1930, as it is today, moving from one type of economy and economic management to another.

> We are suffering, not from the rheumatics of old age, but from the growing-pains of over-rapid changes, from the painfulness of readjustment between one economic period and another. The increase of technical efficiency has been taking place faster than we can deal with the problem of labour absorption; the improvement in the standard of life has been a little too quick; the banking and monetary system of the world has been preventing the rate of interest from falling as fast as equilibrium requires.[18]

In his essay, Keynes sketches the development of modern economies and the immense productivity increases that accompanied technical development:

> In quite a few years — in our own lifetimes I mean — we may be able to perform all the operations of agriculture, mining, and manufacture with a quarter of the human effort to which we have been accustomed.[19]

For Keynes, the great increase in productivity would bring with it the problem of technological unemployment, which he defined as "... unemployment due to our discovery of means of economising the use of labour outrunning the pace at which we can find new uses for labour."[20]

But this, too, Keynes saw as a temporary problem in the transition to a new social stage where the economic problem itself would be solved:

> I draw the conclusion that, assuming no important wars and no important increase in population, the *economic problem* may be solved, or at least within sight of solution, within a hundred years. This means that the economic problem is not — if we look into the future — *the permanent problem of the human race.*[21]

He goes on to note the vast change that will accompany this fundamental shift in the ground rules on which western society has functioned for so long. He predicts that society may go through a type of nervous breakdown. How are people to live without the structure and rules imposed by the need to earn a living?

> I think with dread of the readjustment of the habits and instincts of the ordinary man, bred into him for countless generations, which he may be asked to discard within a few decades . . . to those who sweat for their daily bread leisure is a longed-for sweet — until they get it.[22]

In 1930 Keynes predicted that within 100 years the economic problem would be solved. If he is right, it is slightly more than halfway to a solution. Could the information society be the stage that marks the new age of release from the need to produce commodities? When it is said again and again that society is "commodity rich but information poor," could it mean that the economic problem is capable of solution even now but is not being correctly addressed because of institutional unwillingness to deal with change?

What about work? Today there is much talk of worksharing, a decline in the work week, and sabbaticals for workers. Keynes, in 1930, noted that in the emerging society everyone will still want to do some work:

> We shall do more things for ourselves than is usual with the rich today, only too glad to have small duties and tasks and routines. But beyond this, we shall endeavour to spread the bread thin on the butter [*sic*] — to make what work there is still to be done to be as widely shared as possible. Three-hour shifts or a fifteen-hour week may put off the problem for a great while.[23]

Keynes notes the fundamental shift in values that must accompany such a change. Referring to the compulsive pursuit of money, he writes,

> The love of money as a possession — as distinguished from the love of money as a means to the enjoyments and realities of life — will be

> recognised for what it is, a somewhat disgusting morbidity, one of those semi-criminal, semi-pathological, propensities which one hands over to the specialists in mental disease.[24]

It is worth noting the words of Keynes, the economist whose writings and ideas, it could be argued, created the ground rules for the current economic system. His ideas, expressed over 50 years ago, could well appear in an issue of *The Futurist* today.

> I see us free, therefore, to return to some of the most sure and certain principles of religion and traditional virtue — that avarice is a vice, that the exaction of usury is a misdemeanour, and the love of money is detestable, that those who walk most truly in the paths of virtue and some wisdom are those who take least thought for the morrow. We shall once more value ends above means and prefer the good to the useful.
>
> . . . But beware! The time for all this is not yet. For at least another hundred years we must pretend to ourselves and to everyone that fair is foul and foul is fair; for foul is useful and fair is not. Avarice and usury and precaution must be our gods for a little longer still. For only they can lead us out of the tunnel of economic necessity into daylight.[25]

For Keynes in 1930 the change had already begun.

> But, of course, it will all happen gradually, not as a catastrophe. Indeed, it has already begun. The course of affairs will simply be that there will be ever larger and larger classes and groups of people from whom problems of economic necessity have been practically removed. The critical difference will be realised when this condition has become so general that the nature of one's duty to one's neighbour is changed. For it will remain reasonable to be economically purposive for others after it has ceased to be reasonable for oneself.[26]

Income Is Needed for Those Who No Longer Need to Work

In the September 1982 issue of *Scientific American,* Wassily Leontief set the groundwork for some of the changes Keynes predicted 50 years earlier. Leontief notes that in the past, workers displaced by advances in technology-induced productivity eventually found jobs elsewhere; nowadays, information technology appears to change the conditions for further employment:

> There are signs today, however, that past experience cannot serve as a reliable guide for the future of technological change. With the advent of solid-state electronics, machines that have been displacing human muscle from the production of goods are being succeeded by machines that take over the functions of the human nervous system

> not only in production but in the service industries as well . . . .The relationship between man and machine is being radically transformed.[27]

Leontief's message is that, if an economy is to function, the work not done by machines must be shared and so must the income. A decrease in the working week is the first step, for Leontief, to accommodating the new technologies successfully.

In the transition to an information economy, the roles of all social institutions and activities are transformed. The connection between work and income, which made sense in a time of material scarcity, now leads to social inequity and, at the limit, could undermine the economy. In a society in which the automation of production and services is the norm, the displaced workers who cannot purchase products will suffer as individuals, and their collective decline in effective demand, triggering an economic recession or depression, would lead to social suffering on a broad scale. Simply stated, in a postindustrial society it is more important to be a consumer than to be a producer of still more goods.

Profound institutional innovation is needed to match the technological innovation that marked past decades. Income distribution will in future have to take place through a variety of old, new, and as-yet-unimagined mechanisms. Many job-creation projects are merely costly mechanisms for distributing income. After a few years the subsidized factory is closed down and the workers are back on unemployment or welfare. Imaginative mechanisms are needed for distributing purchasing power without creating a more costly social infrastructure, more capital-intensive factories, and new office towers. Policies that will allow people to stay in their regions and communities while maintaining their standard of living could turn out to be the most socially expedient.

The necessary economic changes may turn out to be the easiest to achieve. It will be more difficult to achieve:

- a change in the educational system from one that trains people to earn a living to one that educates people to cope with living;
- a change in the values and attitudes that underlie and promote the work ethic;
- a change in the prevailing belief that work in the marketplace is more important than voluntary work in the community or work in the home.

The transition to an information society has sparked a debate about the role of work, leisure, and education in society.[28] The debate at once reflects the changes under way and demonstrates how much more social change and understanding is needed.[29]

Information Technology Is Leading to an Information Economy

The early 1970s saw a debate on the role of material growth (how much, for how long). Charles Reich's *The Greening of America, The Limits to Growth* by the Club of Rome, and, closer to home, the Science Council's Report 27, *Canada as a Conserver Society: Resource Uncertainties and the Need for New Technologies* all dealt with the issue of the limits to material production. With the development of information technologies that save on energy, labour, and capital, new voices are restating the same problem/opportunity of potential material abundance in different ways.

> But now that mechanical industry has come to the end of its growth and of its ability to create wealth, now that most of us wear clean clothes and manipulate information rather than things, now that growth is all resources and high-tech, now that we have entered the information era, dominated by trade in information, it is becoming increasingly difficult and costly and meaningless to give information away. . . .As more of us make our living from information, we come to expect to pay for it, with our money, or our time, or both. And if we have to pay for it, . . . we prefer to buy the best in the world, now that so much of it is so easily available. We haven't got time for anything less than the best. "After all," as the advertisement says, "I'm worth it!"[30]

In the information age, where information is power, or money, or control, it will increasingly make sense to charge for its use. In the early part of the 20th century, when goods were scarce, the government ensured that all citizens would have equal and free access to information in the form of the public library. In the future, the situation may turn around completely. Goods will be in great supply (either actual or potential) and may therefore be "given away" (in the form of food stamps, for example). Already one United States bank is giving away videotex terminals to those who subscribe to its electronic funds transfer service. We are moving into an age of throw-away hardware. The real source of value in the future will be the packaging and distribution of information – selectively and efficiently. Information, either alone or "wrapped around" a service or product, will be the new product of the information economy.

Japanese economist Funai Yukio states the problem succinctly:

> Our age is one of an overabundance of goods. While it may be possible to force more products through the market for a few years longer by making an extra effort, looking ahead 10 or 20 years, we can see that industrial circles need to implement a complete change in strategy even at the risk of a degree of financial loss during the transition period. As far as material consumption is concerned, the Japanese economy has reached maturity. It can now be said to have entered a

late-maturity stage or even a stage of decline. Society is putting crass materialism behind it, or perhaps we can say that it is shifting from a material to a cultural orientation . . . .

In the light of this I think that consumers are saying, "We have enough conventional consumption items." In general terms, business enterprises must be forced to realize that to cram any more sales down consumers' throats will be very difficult. If industry treats this as a purely temporary phenomenon and, refusing to discard long-established practices, pins its hopes on the dream of a mass-production, mass-retailing, mass-consumption society, it will eventually reach a dead end.

Attitudes are changing. The age that encouraged material waste to keep the economy going and was characterized by increased consumption and production is coming to an end. A new age is coming to be, one that has cast off the materialistic, bigger-is-better, industry-first way of thinking. In the new age, spiritual rather than material values are in the ascendant, and the economy will have to be re-evaluated in the light of the services it supplies.[31]

Chapter 4

New Industries, New Jobs, New Ways of Doing Things

> On any given work day, perhaps 7 million employed people are paid to spend their time in front of a television screen. They are not watching "General Hospital," but rather, are reading material produced by a computer. These people are airline reservations clerks and travel agents, stockbrokers, newspaper reporters and editors, catalog showroom order-takers, and customer service representatives at telephone, utility, and other sorts of firms. Among the 7 million, there are secretaries and, to a small but increasing extent, executives. They clearly have many different jobs and levels of responsibilities, but they all share one trait: more and more, they are using the computer for some portion of their information storage and retrieval. And instead of using a computer specialist as an intermediary, as they would have done only a few years ago, they are interacting directly with the computer. This means that much of what they read appears on a video display terminal — a VDT — instead of in ink on paper.[1]

New hardware, new software, new content, new skills, new jobs, new industries. The automobile age brought with it jobs in the auto industry, but it also led to the creation of whole new industries: shopping centres, suburban development, petroleum sales and related services, highway construction and maintenance, and so on. Similarly, information technologies have created jobs in the building of microcomputers, and wealth for those who can provide interesting, educational, and entertaining content. Americans spent more than $8 billion on video games in 1981 — more than on movie theatre admissions and phonograph records combined.

Information technologies make possible the "commoditization" of content; content will more and more become an article of commerce. Content here refers to the vast range of ideas, experiences, concepts, reports, directions, and recipes produced by a society. The most common vehicles for conveying content have been the written and the spoken word and the photograph. Information technology means that content can be stored and retrieved using digital technology, and that it can be delivered to anyone, anywhere in the world.

Satellites eliminate the constraint of distance and radically change the cost of delivering information. Electronic networks make irrelevant the constraints of time. Electronic memory leads to increasingly trivial storage costs. The cost of processing, storing, presenting, formatting, and delivering content is continually dropping. It is now possible to package information in such a way that it can be personalized according to a client's requirements. Or a commodity might be sold because information about an individual contained in one data bank suggested to another data bank that the individual might be interested in buying the good or service. In this case, the service or commodity is "wrapped" in another service — a process made possible by the use of information technologies.

Thus it would be a mistake to think that the information consumed is only an extra, and that the real business of the economy is and will continue to be the provision of food, clothing, and shelter. It is also incorrect to think that services are somehow second-class elements of the economy whose existence and value depends on the exchange of "real" goods.

Information: The Primary Commodity in an Information Economy

The information industries will contribute the major part of the future gross national product of Canada. Goods will be sold as part of a total information package. In fact, it is altogether likely that more of the goods industry will depend on the information industry than vice versa. The use of televisions, telephones, computers, communications satellites, microwave networks, typewriters, and so on already depends on the content provided by information activities. Unlike houses, shoes, and doughnuts, these products are useless in themselves.

> It isn't difficult to think of several large information sectors that will grow into mainstays of the economy. Entertainment is an obvious candidate, already an important element, and so are the news media. Education is another, already extending backward from kindergarten and forward from university, taking in training and retraining, and now reaching toward all kinds of self-development. Communications of all sorts, from mail and telephone calls to video conferences and computerized Delphi probes, are expanding rapidly. Accounting, business and economic statistics, market information, all kinds of government records, now make up a significant work activity and must surely continue to expand.[2]

Almost all professions are involved in classifying and interpreting special kinds of information. What is a lawyer or doctor or engineer but someone who organizes information? All management work is also in this sense professional. Most of the people who work in the service sectors are primarily concerned with information.

Information is the raw material of the new economy.[3] An information economy is therefore one in which information is the main capital input leading to growth and development. Information is central to manufacturing, services, and the operations of government. The activities of inquiring, communicating, evaluating, and deciding have become predominant. In industry, the "need to know" fuels the search for information on which business decisions are based. The corporation is slowly evolving into a kind of information-rich, organic learning system that transforms data from various sources into the capital knowledge base on which the corporation ultimately rests. Information is consumed by business and, in a different form, is consumed at the level of the household.

"To describe our business as one that traffics in paper, ink, and type is to miss the point entirely. Our real enterprise is ideas and information." A quote from a futurist? Perhaps. This is the strategic outlook of W. Bradford Wiley, chairman of John Wiley & Sons, one of the oldest publishing houses in New York City, and publisher, in the 19th century, of Herman Melville, Nathaniel Hawthorne, and Edgar Allan Poe, and most of the first American editions of John Ruskin. Wiley adds, "Until now, our medium has been the bound book; tomorrow our medium will expand to include [computer] data banks and video discs."[4]

The information economy places a value on all sorts of content. That content is turned into a commodity and sold. Whether it is a pornographic film on a cable channel, or a videodisc walking tour of Paris, or a satellite weather map, the information or content has value to someone. As such, it can be sold. Someone can make a profit. Someone will have a job. Taxes will be paid. The economy continues, but it has a different shape. It has a different configuration and tempo.

Information derives its value in many ways. It has value to those industries that manipulate fashions and mould public opinion. Political parties also spend vast amounts of money for information of this type. Information also has inherent value, which can be sold. This inherent value, which is unattached to material objects, is what is sold through courses that help students pass university entrance examinations. Such information is now a popular commodity.

Information is also valuable because it allows an individual to make more efficient use of time. The "productivity of information" is illustrated in the following scenario:

> By virtue of [belonging to a particular network service] consumers who are group members will be able to achieve the same level of efficient time use as that enjoyed at the moment by executives in top corporations. Suppose you have three free hours and would like to spend them shopping, eating, or enjoying some form of entertainment. To determine the alternatives, you call the information centre via your terminal, and it supplies you with information on how to use this time most efficiently — what shops to go to, what restaurants to eat at, or what movies to see. After your choice is made, the infor-

> mation centre will take care of all necessary arrangements — calling a taxi, reserving a table, or procuring a movie ticket after confirming that seats are still available.[5]

In effect, such a service would mean that everyone would have a personal concierge. People would provide the computer with an outline of their interests, enter their credit card numbers, then pay the bill and enjoy. Science fiction? According to Professor Yukio, such a venture is now starting up in Japan.

Information Technology and Consumer Goods

Developments of this type are not restricted to Japan. Not long ago the *New Yorker* magazine related the story of Emily Cho, who set up a mail-order fashion-guidance service in the United States using a specially programmed computer.[6] Miss Cho's clients fill out a multiple-choice questionnaire about the image they seek to project ("authoritative and formal" at work, perhaps, and "exotic and dramatic" in the evening) and modifications they would like to make to their characters (perhaps they feel "too aggressive" or "too meek"). The computer matches these goals with information about the clients' sizes and shapes to come up with suggestions for building or improving their wardrobes. The greatest number of clients, it seems, are working women who want speedy help in finding clothes that will look right or, better yet, help them to get ahead.

> Miss Cho told me recently that it had been a laborious matter to program the computer to her satisfaction after she had isolated the specific message projected in our society by a women wearing, say, a ruffled blouse or a hand-knit vest. Then, when she set the service in motion, her first instinct had been to draw the clients' attention away from the idea that their private hopes and dreams were being fed into a coldhearted computer. But it was soon brought home to her that the idea of the computer was precisely what appealed to the women. They welcomed the involvement of technology, because they could believe that the clothing suggestions were particularly accurate and scientific. To some extent, they liked the endorsement of the machine. What they demanded was a clear-cut formula for dressing well, rather than capricious ideas springing from another woman's brain. At the same time, Miss Cho found, they needed to believe that that other woman — Miss Cho herself — was somewhere around, to supervise, and reassure them that they had not turned over the serious, delicate question of their image to a distant, possibly runaway machine. She concluded that what clients wanted was not the obtrusive presence of an actual person in the business of guidance — dealing with a real person requires just the sort of time and effort they wanted to save — but the ethics of that person, somehow lingering in the technology like a perfume after its wearer has left the room.[7]

In the future, a computer-based fashion guide might be linked to videodiscs or to a videotape that discusses and shows the season's fashions. Such a service might dispense not just guidance but the clothes themselves, from a store or a warehouse, whose inventory, inevitably, would be stored in computers.

By some estimates, the mail order business has increased 1000 per cent during the past 10 years. Shopping by mail, customers save time and gasoline; if they order over the telephone and use a credit card number, they also save the cost of writing a cheque and mailing an order.

> Merchants try to create the idea that it's all fun — a way of capturing a customer's imagination — and not just practicality. Great care and expense go into the production of catalogues that are more and more like magazines, with top photographers presenting top models on ambitiously designed pages. Bloomingdale's has set some dramatic examples in the catalogue genre: a notoriously provocative lingerie booklet, photographed by Guy Bourdin; the issue for its China extravaganza, with fashions looking decadent indeed in photographs showing models in paddy fields next to bent-backed peasants; and the current offering, which has several of the highly publicized young Lolitas of the model world photographed by Francesco Scavullo.
>
> Gradually, our attitude toward shopping is being transformed, and, with it, our expectation of what we hope to find when we leave home to visit a store. The large, impersonal department store with a wide choice of basic goods and a large staff of salespeople appears to be an institution that is on the wane. Its origins were in the nineteenth century and embodied two by now somewhat outmoded nineteenth-century notions: stores as great celebratory hymns exalting the glories of mass production and expanding markets; and institutions whose sales counters would always be manned by an infinite force of courteous, humble workers. The department store's function as a supplier of goods is more efficiently performed by an impersonal warehouse and a personal-seeming catalogue — currently a printed booklet but in time, presumably, in video form. For many years now, it has been inadvisable to seek courtesy, or even attention, from salespeople in department stores. Service is more likely to be found in boutiques and specialty stores, and shoppers who depend on it will seek out such places.[8]

Information technology will accelerate current trends that augur the demise of the vast, anonymous department store. The new computerized, personalized shopping experience will be different. Routine purchases such as groceries and basic clothing will be routinely ordered and paid for using video display terminals; the products themselves will be delivered (or picked up) from a central depot.[9]

The change in the method of shopping will mean that people employed by "stores" will have to have new skills. New ways of doing things will result in the creation of entirely new occupations and different expectations about the skills needed in old ones.

Job Specifications Will Incorporate Information Technologies

One indicator of the changing economy is the demand for new information skills in the workplace. The Harvard University Program on Information Resources Policy conducted a survey of the help-wanted advertisements in the *New York Times* for the same day in June from 1977, through 1982. The researchers counted the number of job descriptions that mentioned some "computer literacy" skill, such as word processing, programming, data entry, and so on. In 1977 5.8 per cent of the job descriptions specified those skills. The percentage increased regularly to 1982, when 10.3 per cent of the jobs listed required such skills. Perhaps of equal significance is the way these jobs were described. Earlier in the period, employers would specifically seek out a "Wang operator" or "word processor." By 1982, however, they were back to looking for secretaries having "experience with word processing" or "knowledge of Sabre" (a computer system for travel agents). This trend demonstrates that, as new technology becomes more commonplace and the skills associated with it become more widespread, those skills become incorporated into traditional jobs. When the power saw was a novelty, building contractors sought out "power-saw operators." But later, when most carpenters were expected to have some familiarity with this tool, contractors again began to seek out carpenters as such, carpenters who had, among other skills, knowledge of the power saw.

In 1977 none of the help-wanted advertisements for travel agents mentioned any sort of computer skill; in 1980 one-fifth of them mentioned a computer-related skill. By 1982, as a consequence of the implementation of computer reservations services by the industry, 71 per cent of the job openings in the travel business required some computer skills. Similarly, the number of bookkeeping jobs requiring computer-related skills doubled to 24 per cent between 1977 and 1982; the proportion of job openings for secretaries and typists who had word processing skills went from zero in 1977 to 15 per cent in 1982; and the number of jobs that were labelled "word processing," or that specified the ability to use a word processor, increased eightfold in that period, despite the recession in 1982 and a decrease in the number of job openings overall.[10]

Increasingly, computerized systems are being introduced to air traffic control. In the United States the Federal Aviation Administration (FAA) is making plans to change the nature of many air traffic controllers' jobs significantly. In 10 years, and at a cost of $1 billion, the FAA hopes to have computerized en route air traffic control to such an extent that at least 50 per cent fewer controllers will be needed; those that are needed will be computer managers.

The FAA plans to develop a system in which sophisticated transponders on airplanes communicate with air traffic control computers. The computers would be programmed to determine optimum flight patterns to ensure that planes do not collide and to clear planes along their routes. The advantages of such a system would be fuel savings, increased passenger safety, reduced stress for controllers, and increased worker productivity.

Today, aircraft frequently fly at low altitudes or on circuitous routes simply because there is a limit to the amount of information the mind of a human air traffic controller can handle. Both procedures waste fuel. Because computers can keep track of more airplanes and can be programmed to design optimum flight paths for them, the automated air traffic control system should save substantial amounts of fuel.

In addition, an average of 1.5 air traffic controller errors occur each day in the United States. Half of these errors are caused by a lack of coordination between controllers, or by controllers' inattention, lack of communication, or poor judgement. Such errors would be eliminated by the new computer-based system.

How will all of this affect the job of the air traffic controller?

> Controllers will have to be retrained and the selection criteria for new controllers will have to be changed. "We will be more computer-oriented in our selection," says a spokesman for the FAA. "The people we have now are used to making quick decisions. They get bored sitting around." However, when computers make the critical decisions, sitting around will be a large part of the job.[11]

New Activities Lead to New Industries

The creation of an information infrastructure will lead to an expansion of old markets and the creation of new markets. Movie production will increase to supply the range of educational and entertainment material needed for pay television and home video cassette recorders. The field of security services will emerge as a logical adjunct to the information infrastructure. Either the cable or telephone company will offer home security or medic-alert services for a few dollars a month. People will be hired to monitor alarms and install systems. Newly created databases will offer many new kinds of information, including sports results, entertainment, news, classified advertisements, stock exchange (and industry-specific) information, medical and pharmaceutical information, *Hansard,* and law. Many people with various skills will be needed to construct and update these databases.

Although computer shopping has the potential to eliminate many current retail jobs, new jobs will be created in developing new ways to display and market products and services. The creation of shopping catalogues on videodiscs, for example, will lead to a whole new industry.

Special interest computer networks might be created. These could consist of people who share interests in, for example, opera, chess, heritage buildings, sports, or poetry. Once the network is created, it will need somebody to serve it, write a newsletter, organize a convention, and compile a database. This type of activity might ultimately provide 10 times the employment and revenue that is now being generated by all the special interest magazines that have sprung up in the past decade.

The application of the new technology reflects the morals and ethics of our society, so it should be no surprise that softcore pornographic software has already made an appearance. Programs such as Interlude, Softporn, and Pornopoly (a strip-poker computer version of Monopoly) are now on the market. The best-selling commercial program is Interlude, which has sold over 15 000 copies at $21.95. Other games will no doubt be created for the current readers of Penthouse, Hustler, and other borderline pornographic magazines.

The x-rated movie viewed on a home video-cassette recorder is based on passive broadcast technology. But similar material viewed using computer-controlled laser discs allows the viewer to interact with and control programs. Laser discs having 54 000 video frames per side will allow viewers to choose alternative scenes, freeze images, backtrack, and so on. Provided with a voice-over (male or female or both) and mailed directly to the home (as videodisc of the month) by Penthouse or some other enterprising firm, such products are likely to be very profitable.

Among other computer services now being prepared is telegambling. In the future, football pools and horse racing could be run through interactive videotext or computers. Access fees could be automatically deducted from a player's account, and background information on horses or football teams could be obtained from the computer. Bets could be placed up to the start of the event. Needless to say, winners would automatically have their prizes transferred to their bank accounts through an electronic funds transfer network.[12]

Teleroulette, teleblackjack, and even an updated version of the "one-armed bandit" are all theoretically feasible using interactive computer systems, random number generators, and electronic funds transfer systems.

Interactive computer technology has made possible the creation of "electronic novels" that allow readers to choose from among a variety of plots. Simon and Schuster, Inc., for example, intends to market a series of computer-based "what if" novels, including *What If Lincoln Had Lived?*, which lets users explore the consequences of a hypothetical historical event. In a series of romance and mystery novels, "readers" can control the sequence of events in the novel to arrive at different outcomes.[13]

The above examples have been included to show that the new technology will modify most of the ways in which we, as a society, express ourselves. It is a medium that can be harnessed for the wide expression of human emotions — from pornography to education to research to diversion. In the process, whole new industries will be created, and the notion of work and working will change. In fact, we will witness a blurring of the distinctions among work, education, leisure, and entertainment.

The information society and its underlying economy will create a demand for intellectual labour and for new ways of supplying information to clients. Already available are a number of specialized information services oriented to users' needs and interests. Bibliographic information and technical abstracts will increasingly be supplied on special networks.

New jobs will be created for those who can read documents, summarize them, and send brief abstracts to decision makers. Knowledge engineers will be needed to create and upgrade expert systems (now a branch of artificial intelligence). To create an expert system requires many person-years of intensive research and analysis.

What kinds of services will people buy in an information economy? Below is a partial list of services already available to Canadians, or that are currently being planned or developed:

Information: newspaper stories, wire services, stock market information, company financial reports, weather information, road information, consumer information, electronic mail services, air and rail schedules and ticket purchases, travel tips and reservations

Library Services: catalogues, abstracts, encyclopedias, book reviews, reference books, key word searches, interlibrary loans, book ordering services

Games: chess, adventure, mazes, computer modelling

Education: grade school, high school, college, university, computer-assisted instruction, teaching games, computer simulation

Shopping: catalogue shopping, direct marketing, market research, product demonstration, information on production, operation, and maintenance, price and product comparisons

Security/Protection: intrusion alarms, fire detection, medical alert

Energy Management: meter reading, thermostat setting and control, water-heater control, time- and load-sensitive energy pricing

Entertainment: pay-television, pay-radio (records on demand), audio information services, quizzes, jokes, stories, interactive programs (user determines outcome), restaurant information, music, theatre, dance, visual arts

Government: services, voting, job opportunities

Personal: classified advertisements, dating/matchmaking, bulletin board, community events, teleconferencing, voice messages, telephone answering, work at home, daily calendar/reminders

Financial: record keeping, budgeting, tax-return preparation, list and calendar maintenance, investment information, financial planning, mortgages, insurance, research, computation services

Banking: chequebook and credit card statements and updates, direct bill paying, cash management, account transfers, savings bond and deposit certificate purchases, loan agreements[14]

It is estimated that already $1 billion a year is spent retrieving information from electronic libraries and that this sum is growing by 30 per cent a year. A user in California can telephone a library in England, punch a few key words into a computer terminal and discover within minutes an obscure piece of information that might otherwise have taken hours, perhaps days, to locate.

At present, there are about 650 publicly available databases to choose from. Typically, they provide only abstracts of learned articles. The user then has to rely on old-fashioned technology to get a copy of the full article – in other words, somebody has to go to the library and make a photocopy.

Nevertheless, electronic libraries are a big help in finding one's way through the growing technical literature. Almost a decade ago, it was estimated that 500 000 pages of technical reports, scientific journals, and books were produced every minute. The number may now be much higher. Thanks to electronic libraries, over 40 million articles can now be searched almost instantly.

The cost of using such a library is on average around $75 an hour and varies from $1.50 to $120 an hour. This variation in cost partly reflects what the supplier of the information thinks users will pay and partly the cost of the telecommunications link to the library. In the United States, the telecommunications charge is relatively low, reflecting the freedom of information providers to select from among competing delivery systems.

There are currently three main types of information for which users are currently prepared to pay the high cost of electronic libraries:

Patent information: A company can waste millions of dollars developing a product only to find that somebody else already holds a patent on it. This situation can be avoided by searching through all existing patents. Electronic libraries make it possible for this to be done very quickly. The market leaders in providing this service are Systems Development Corporation in the United States and a relative newcomer, Pergamon Infoline, in Britain. Their databases contain all the patents filed with the United States Patent Office since 1971 — some 700 000 of them. Both companies add 5000 patents a month to their libraries. Pergamon is currently launching a system that provides drawings to go with the written records of a patent.

Medical and chemical information: The American National Library of Medicine has compiled a database, called Medline, that catalogues over 3000 scientific journals and indexes 20 000 articles a month. Its chemical equivalent, called Chemline, catalogues the formulae of chemical compounds rather than articles about chemistry. But its Toxline service contains over 600 000 references to articles on the safety of chemicals.

Legal information: A service called Lexis gives lawyers easy access to case law from both American and British courts. Operated by an American firm, Mead Data, the Lexis system differs from most electronic libraries in providing the full text, rather than just an abstract, of a report — in fact, Lexis contains over five billion words.[15]

New Activities Lead to New Employment

To operate the many new services — the banks, the shopping services, the mail services, the information services — workers with both traditional skills and computer-related skills will be needed. Shortages of such workers are already occurring. The demand for computer programmers in the United States today already exceeds supply by at least 50 000, and that gap is likely to widen as the use of computers becomes more widespread and the demand for software accelerates. Barring major changes in software technology, the overall demand for programmers in the United States could reach 1.5 million by 1990, more than three times the number of programmers working in the United States today.[16]

In 1982, the worst year for business since the "great depression," Northern Telecom had to hire 800 new scientists and engineers to maintain its rate of expansion in research and development in electronics and telecommunications technologies. The chairman of Northern Telecom noted that his company will be hiring 400 people a month, every month, until 1987 — in almost every discipline and profession. "By the end of the decade, we anticipate we will have had to recruit up to 65 000 people, almost twice our present worldwide employment."[17]

So fundamental is the software shortage that it has led to the rise of a brand-new industry — the independent software business. Barely 10 years old, the software industry is booming. Software companies are taking some of the burden off computer users who otherwise would have to write their own programs. Independent software retailers are selling standard, off-the-shelf packages of the two basic types of software: applications programs, which automate specific chores such as payroll, accounts receivable, and basic inventory control; and systems software, the computer's internal management system, which handles "housekeeping" activities. Because the same program is sold to scores of customers, vendors are able to price their products at only a fraction of the development cost. Already, independent software companies in the United States offer more than 8000 software packages and serve more than 30 000 customers.

The University of Waterloo in Ontario has achieved considerable success in the marketing of software. The university currently sells software to 3000 users worldwide and has a greater revenue from software than the Massachusetts Institute of Technology and Stanford University combined.[18]

The need for programmers has led to the creation of a new industry that sells standard program packages. Similarly, the need to make effective use of computers has led to the development of the systems consulting business as one of the fastest growing fields in Canada today. Because systems are important in the day-to-day operations of most businesses, consulting companies are becoming important factors in the effective operation of computers. Systems consultants help meet their clients' demands for systems specialists and provide advice about how the client firm can use its equipment more effectively.

New Commodities: Video Games and Software Packages

Software in the consumer market has, to date, made its greatest impact in the form of video games. In the same way that the invention of the phonograph laid the foundations for the record industry, the home video game is helping to create another industry, one that markets content or software. More precisely, this industry produces cartridges that contain the digital programs, or software, for different video games.

A prototype of such a firm is Activision, Inc., of Santa Clara, California. In 1980-81 the firm produced more than five million units and earned gross revenues of more than $50 million, or more than 60 times the amount of its original investment.

To win a major share of the market for computer games, Activision relied heavily on the talents of its four founding game designers, who were collectively responsible for more than half of Atari's cartridge sales before they left to form Activision. "The guys who design games are not engineers or programmers," says the president of Activision. "They have as much creative talent as any performing artist or author."[19] The president promotes game designers as if they were rock stars. The instruction sheet for each game includes a picture of its designer, along with his or her tips on playing the game.

A top-selling game can produce impressive profits. For example, in 1981, with only 50 employees, Activision had little overhead — and its manufacturing costs were kept relatively low. Each cartridge consists of a simple plastic housing containing a semiconductor memory chip that stores the game program, plus a few small springs to hold the plug-in cartridge in place. The total cost of materials is less than $4. In 1981, Activision charged more than $10, on average, for each game cartridge. Small wonder, then, that industry analysts have concluded that the profits in video games are in the software, not the hardware.

Activision officials predict that sales of video games will have levelled off by 1985. But by that time they intend to have moved into a new growth business — selling software to users of home computers. Since home computers are more powerful than video-game machines, game software could become even more sophisticated.[20]

The new games coming on the market combine the laser disc with the computer. Still to be found only in video arcades, the laser-disc video game produces high-quality sound, more realistic images, and gives players more control over game events than do the conventional computer-based games. Cinematronics of San Diego, California, produces a laser disc game called Dragon's Lair. Others are being developed but will probably not be in home use until inexpensive, reliable laser-disc machines are available for the home market.

The production of software for managers (the famous VisiCalc or Lotus 1-2-3, for example) is a multimillion-dollar industry. Among the fastest growing software packages are database management systems (DBMS). A DBMS is a set of programs that provides flexible and powerful ways of retrieving information from computers. Users of mini- and microcomputers, as well as those using main-frame computers, now want database management systems. Main-frame computer makers once supplied most of the DBMS sold. Small and aggressive independent software companies, however, are now winning more of the orders for DBMS in a business where brains and marketing flair can be more important than corporate size. Sales of DBMS are expected to reach $4 billion worldwide by 1985.

Work and Workers Can Be Anywhere

New jobs and new industries grow, in part, from new ways of carrying out older jobs. For example, since information technology tends to be distance insensitive, the worker can be anywhere in the world communicating with "the office" via telephone lines or satellites. Workers can now be imported — and jobs exported — without the need for anyone to cross national borders. Satellite Data Corporation in New York City is now offering clients the services of experienced data-entry and word-processing personnel in Barbados. The company can do so by transmitting handwritten and typewritten documents as well as dictation via satellite to the West Indies where workers, inexpensive by United States standards, type the information into computers for word processing. Word-processed documents are then returned via satellite to the source and either stored in computers or printed out.[21]

With new technology, workers can even be behind prison walls. Best Western International, one of the world's largest lodging chains, recently opened a reservations facility at the Arizona Department of Corrections' Center for Women in Phoenix. The pilot program employs 30 of the centre's inmates as reservations sales agents. In order to qualify, the applicants had to go through Best Western's standard personnel screening process.

Those participating in the program are paid at the same rate as other temporary reservation agents working for Best Western. A proportion of their salaries is paid to the Arizona Department of Corrections for room and board, state and federal income taxes are deducted, and the remainder is deposited into savings accounts to be paid to the inmates upon their release from the centre.

Inmates in the program agree to adhere to Best Western's employee code of conduct, which includes a dress code. The company's supervisors are present while inmates operate the reservations program to ensure that would-be guests' calls are answered promptly. However, the centre's staff assume all responsibility for security and conduct matters.

Best Western installed 14 video-display terminals in the centre, which operates from 8 a.m. to 5 p.m. There are plans to expand the hours from 6 a.m. to 10 p.m. when additional inmates have been trained.[22]

Competition to provide computer-based services can now take place across time zones. A Swedish company is offering data processing clients in California use of its main-frame computers near Stockholm at prices below those in the United States. The key to the lower rate is the nine-hour time difference between California and Sweden. When the Swedes stop work, Californians are just beginning; thus unused computer processing time in Sweden can be sold in the United States at discount rates. The Swedish firm will offer discount data processing services from 8 a.m. to 8 p.m. California time (corresponding to 5 p.m. to 5 a.m. in Sweden). Data are sent over leased telephone line or by satellite.[23]

The Holiday Inn hotel chain is breaking new ground with its video teleconferencing network. An advertisement in *Business Week*[24] claims "Now you can be in 2 places at one time. Or 20, or even 200." The text of the advertisement goes on to say:

> With the Holiday Inn Video Network, you can be seen and heard all over the nation. Your television presentation is broadcast "live" via satellite to over 250 convenient, local Holiday Inn hotel meeting rooms across the country. You can communicate coast-to-coast with every level of your organization. Accomplish more in less time. Talk to your entire team more often. Get on-the-spot feedback with our two-way telephone hook-up. Our network is perfect for sales meetings, new product introductions, education or training seminars, trade or professional association conventions, franchisee or licensee meetings, and press conferences.

In the United States and Canada, there are over 40 firms (some old, some new) that offer teleconferencing, satellite video, or data transmission services (in an interactive mode). These companies represent the new common carriers using the new information highways. They are now, or soon will be, as important as the airlines, buslines, trains and intercity traffic of the industrial age.

Industries Are Blending, Boundaries Are Blurring

With the introduction of the new information technologies, both established and new firms will increasingly compete for the same markets. So, for example, the telephone, telegraph, computer, software, service bureau, semiconductor, satellite, motion picture, and business equipment firms are focusing on the same customers, wherever they may be: in the office, home, factory, retail store, or bank. Traditional boundaries of industry are blurring and shifting, and it is becoming increasingly difficult to know to which industry a firm belongs. It can be a part of one or many; some old, some new. It may have customers who are traditional consumers, expert industrial buyers, or it may simply be a carrier of information.

Also taking place is a type of product fusion. That is, separate products migrate or are repackaged into a single piece of hardware or a new service. Thus a television set attached to a telephone or cable line can be a telex receiver; a typewriter with logic and memory capability is now a word processor; a standard office copier with memory chips is now an information processor or intelligent printer. Conventional terms denoting a letter, telegram, typewriter, copier, facsimile, television set, or telephone take on different names as products embrace and incorporate logic capabilities.

Product fusion blurs distinct industry boundaries. Twenty years ago the telegraph, printing, travel, computer, mail, package delivery, airline, movie, and broadcasting industries were easy to distinguish. Now it is hard to tell them apart because their products and services overlap.

The fact that industry and product demarcations are shifting has brought about jurisdictional disputes. For example, American Telegraph and Telephone's (AT&T) attempt to automate its yellow pages is opposed by manufacturers of minicomputers, the newspaper publishers' association, and Radio Shack. A retailer of home computers now finds itself competing with a regulated telephone company.

Home energy services display similar industry overlaps and boundary-line clashes. In the United States, the telephone company offers services that monitor air conditioning, lights, heat, and other home information appliances. Similar services are offered by the computer industry as well as the cable television industry.

Electronic mail further illustrates the blurring of industry boundaries. The new competitive mix includes the telephone company, the post office, satellite companies, computer firms, television and data transmission, and facsimile companies. Indeed, satellite relay of computer files and tapes has prompted the United States-based courier service, Federal Express, to offer an electronic mail service that employs satellite channels.

Financial services – especially in the United States – are also under erosion and attack. Consider the candidates: First National City Bank, stock brokers, General Electric, Sears Roebuck, credit card companies, and savings and loan associations. For the typical user, the "bank" may very well turn out to be an automatic teller machine and a toll-free telephone number.

Teleconferencing provides yet another example of blurring industry boundaries. Current suppliers of satellite conferencing include Satellite Business Systems, AT&T, and American Satellite. But Holiday Inn and the Hilton hotel chains will also offer teleconferencing services. As well, public broadcasting stations (such as WETA-New York) promote video conferencing as a revenue source for supplementing public television. The boundary line between hotels, airlines, telephone companies, and television stations is no longer immutable.

Boundary erosion carries with it a geographic dimension. Historically, telephone companies were endowed with exclusive franchises on the premise that entry by others compromised service cost and quality. One outcome of industry deregulation in the United States appears to be the possibility that telephone companies will be able to enter each other's previously exclusive territories on several levels — toll facilities, satellite facilities, local loops, remote terminals, and information services. It appears that an exclusive geographic franchise no longer guarantees immunity to new entrants in the market.

Certainly, information technology has cut the corporation's tie to geographic location. No longer dependent upon bricks and mortar, corporate headquarters can move about a country at will. Given remote access lines to main-frame computers and transportable intelligent terminals, geographic mobility is taking on a new dimension.

With industry, firm, and geographic boundary lines either shifting or totally blurring, the term "the uneasy eighties" takes on new meaning. Change is increasing at an increasing rate. New products compete with old products, new investments with old, new services with old. Product life cycles are changing radically. The product life of a teleprinter is one and a half years; for integrated circuits it is two years; for main-frame computers, four years; and for video display terminals, less than two years. A dynamic product environment raises the stress levels of managers, changes the corporation's perception of pay-back period and, in fact, brings a reassessment in management's perception of time.

A mistake can obviously bring losses. Traditionally, losses in the telephone industry have been rare. Yet the German telephone supplier, Siemans, wrote off $230 million on the grounds that its product had been rendered obsolete while still in the design stage. Rapid obsolescence and associated losses are no longer reserved for the computer industry alone.

The pace of change affects decisions of price and cost. Whether in fibre optics, satellites, terminals, computers, communications networks, or private branch exchanges, the rate of cost reduction brought on by massive increases in productivity appears to be accelerating. To the extent that innovation and obsolescence continue to grow, rapid and appropriate management decisions and institutional flexibility will be an important factor in corporate success in the 1980s.

Perhaps the prime example of the new firm is Warner Communications. It is concerned with the creation, production, and communication or distribution of information and entertainment to consumers, chiefly at the household level. It embraces many industries such as television and radio broadcasting, cable television, satellite services, newspapers, magazines, information services, films, electronic publishing, recorded music, videocassettes and videodiscs, and business and consumer electronic hardware and software.

Warner Communications, which began to take shape in 1969, made significant corporate moves in the 1971-81 period, through the 1972 purchase of Cypress Communications Corporation, which more than doubled its cable television subscriber base; the 1976 purchase of Atari, an electronic video game company; the 1977 introduction of Qube interactive television; the 1979 sale of half its interest in its cable television business to American Express; and the acquisition of the Franklin Mint.

In sum, a new type of competition is evolving. It is one thing for firms to compete within the clear boundaries of an established industry. But if industry boundaries are blurring, then rivalry takes on a new dimension. During the 1980s product and service substitutes will multiply and expand. That condition will inevitably increase and intensify risk and uncertainty. Nor is there any indication of an abatement in technological innovation. The uneasy eighties, a time of transition, will be challenging for the private sector, for workers, for policy makers, and for consumers.[25]

New Technology Leads to New Industries

The changes wrought by information technology are so rapid that to keep abreast one has to read the papers daily. In fact, the newspaper industry itself is being revolutionized by the new technology. The *Globe and Mail,* for example, is sent from Toronto by satellite to a number of places in Canada where it is printed on local presses for rapid early-morning distribution. Information technology has transformed the geographic market of the *Globe and Mail* and has made it a presence and a competitor in areas where, because of distance, it would otherwise have been out of date before it arrived.

The new information technologies give new meaning to the term "staying in touch." Portable telephones are appearing on land and in the air. And if military technologies continue to be adapted for civilian uses, there may soon be land-based mobile telephones capable of bouncing signals off satellites to anywhere on earth.

Portable telephones in airplanes are being introduced this year by the new company Air Force. The technology will allow airline passengers to make telephone calls in flight. To date, 12 airlines in the United States have signed up for the service. In early 1984, with 1000 planes carrying Air Force equipment, and with calls averaging 50 per day per plane at $10 per call, a new multimillion-dollar industry was created.[26]

Another new industry that has dramatic growth prospects is ground-based portable telephones. Currently, each mobile phone in a car, for example, communicates with a central station where the call is switched to another mobile phone or to a stationary phone located in a home or office. This system works well, but there is a limit to the number of mobile telephones that can operate in each city.

The system now under development is called cellular mobile radio. The technology takes its name from the subdivision of the city into many cells. Within each cell (which can be as small as a city block) a phone operates on a frequency that will not interfere with a telephone on the same frequency in an adjacent cell. As the mobile phone moves from cell to cell, a computer senses the movement and hands over the call to another frequency (or to the same frequency if it is currently unused), thereby vastly augmenting the potential number of users.

Dramatic increases are apparent in the numbers of new firms, new industries, and new jobs based on the still rapidly expanding and fast-developing new technologies. The five-year-old personal computer market is changing week by week with announcements by new or existing firms. New players are entering the personal computer market every week. At the same time, the method of distribution has changed radically. No longer does the company representative visit the consumer; now the customer goes to the computer company or computer retail store to buy the machine and related software. With computer prices falling, standard software proliferating, and continuing publicity stirring up public interest, many companies are vying for positions in computer retailing. Tandy Corporation's Radio Shack division has already become a major success story. Now, Radio Shack is being joined in the retail computer marketplace by three other groups — independent speciality chains, mass merchandisers, and computer manufacturers themselves.

The fastest growing of these merchandisers are the speciality chains, such as ComputerLand Corporation, which opened its doors in 1976. The company, based in San Leandro, California, operates 200 franchises across the United States and is moving swiftly to intensify its grip on the market. ComputerLand has a growing number of competitors, including CompuShop, MicroAge, and Computer Store. Generally, the retailer's strategy is to carry a broad range of goods from various manufacturers, price them competitively, emphasize software, and sell the expertise and experience of store personnel. The established mass retailers such as Sears, Eaton, the Bay and, in the United States, J.C. Penney and Montgomery Ward, are trying to play a special role. They hope to attract a large share of the volume market by concentrating on low-priced, compact machines that need little explanation or support.

In an effort to control costs and reach new customers, manufacturers have also set up retail stores. With International Business Machines leading the way, Digital Equipment Corporation and Xerox are opening chains to sell business equipment. Meanwhile, Control Data Corporation will focus on selling business services in its store network.

Adding to the pace of change are new technologies such as laser videodisc storage, which could make existing data storage methods obsolete overnight. When commercially available, laser disc technology will provide storage capacity at a fraction of today's costs.

Voice processing, another rapidly developing technology, converts human speech into digital form for computer processing and converts computer-generated data into human speech. Voice processing equipment falls into two categories: voice data entry and voice response equipment. Voice data entry equipment allows users to speak information into a computer instead of keying in information or feeding specially-prepared sheets of type into an optical character reader. Voice response equipment allows the computer to deliver information verbally rather than visually via a video display terminal or printer. Mechanically synthesized speech or prerecorded human speech is used to give the computer a voice.

The impact of voice processing technology is expected to be relatively small during the first half of the 1980s, but will increase dramatically during the second half of the decade as the technology advances and its cost declines. Some important potential applications of voice processing include assembly line manufacturing, credit authorization, banking, office systems, and consumer products.[27]

The marriage of videodisc technology and microcomputers opens up another new industry that is certain to generate billions of dollars in sales and thousands of jobs.

Anyone who has ever planned a vacation to a little-known place will appreciate videodisc technology. Before long, travel agencies will be able to show customers videodisc pictures of just what an intended vacation spot looks like. At the same time, computer-stored room rates, airline schedules, and other information could be displayed over the video image.

For some years, videodisc systems have been used by the military and a few industrial companies for training programs. General Motors Corporation and Ford Motor Corporation, for instance, use videodisc systems to train dealers and teach repair people. However, these systems are relatively unsophisticated and not much more than video phonographs. Now "smart" videodisc systems incorporating microprocessors are about to enter a variety of consumer and commercial markets. Products in the offing include an automated salesperson, educational laboratories, and training manuals.

One of the most interesting consumer-applications of "smart" videodisc systems may be the shopping arcade. Such an arcade would contain free-standing, kiosk-like terminals. Units dedicated to selling a particular item will emit a recorded sales message when approached; others will respond to a touch on their video screens. In Sunnyvale, California, a year-old company launched by video game inventor Nolan Bushnell is preparing a prototype of a remote shopping terminal that will allow a customer to insert a credit card, receive a video presentation describing selected items, and, using the computer keyboard, order a product that would be delivered to the home and charged to the buyer's account number.[28]

Videodisc encyclopedias are also possible. The Academic American Encyclopedia company of Princeton, New Jersey has produced an experimental videodisc to explore the creative possibilities and the technical requirements of the new communications medium.

Selected materials from the *Academic American Encyclopedia* — a 21-volume general-purpose encyclopedia published by Arete in 1980 — have been transformed into images stored on a preprogrammed videodisc that makes use of the interactive potential of the optical-laser disc player. The videodisc presents the full text of selected articles as well as all appropriate illustrations from the encyclopedia. Sound and motion have been added where necessary to enhance the learning experience. Although the information stored on the experimental videodisc occupies just one side, the viewer would need between four and five hours to review all the material on the disc.

The videodisc, created to demonstrate the potential of the technology, contains the contents of over 20 articles from the encyclopedia.

The promotional material issued by the company lists the following "articles":

Ludwig von Beethoven: This biography of Beethoven, complete with bibliography and supplemented by several contemporary illustrations from the period, contains short segments from the fifth symphony and the 12th string quartet — thus permitting a comparison between the musical forms and between the style of Beethoven's heroic period and the later, more serene style that characterized the last decade of his work.

Dinosaurs: The coverage in this topic is extensive. In addition to the general article and a time chart showing the evolution and dominance of each major family over several hundred million years, the videodisc contains specific articles on individual dinosaurs and on the three great geological periods in which dinosaurs were the dominant animal forms. The sequence is extensively illustrated with full-colour drawings created for the encyclopedia. Each illustration is commented on by spoken narration.

Gettysburg Address: Carl Sandburg's reading of Lincoln's Gettysburg Address is accompanied by several images as well as the slow scrolling of the complete text — a format that blurs the distinction between entertainment and education.

Hydrofoil: This article shows not only a sophisticated cutaway drawing of the inside of a hydrofoil, but also a short motion sequence of the craft skimming across the surface of the water, supported by its submerged foils.

Martin Luther King, Jr.: This is certainly the most dramatic article, one from which the viewer can derive some sense of the emotional impact of a particular man and moment in history. The viewer has an opportunity to hear a segment of King's moving "I Have a Dream — Free at Last" speech from the march on Washington, D.C., in 1963.

All the articles on the disc are under the control of the viewer, who can switch rapidly from article to article, take as much time as necessary to read the text, or skip the text entirely and go directly to illustrations, sound, or motion sequences. Thus, the videodisc encyclopedia transcends some of the limitations of literary or reading fluency — a five-year-old will get almost as much out of the articles as a high-school student because of the amount of interesting information crammed into the spoken "captions."

Work and Working and the Transition to an Information Economy

Information technologies are transforming notions of work and working. Inexorably, day by day, week by week, the ground is shifting. But the costs and benefits of change will not be evenly distributed throughout society — they rarely are.

The neatly compartmentalized activities that marked the earlier decades of this century are giving way. Industrial sectors are blending; products, commodities, and services are being integrated, repackaged, and served up as new items to be produced, sold, and consumed. Most profound for the individual, perhaps, is a blurring in the definitions of the major aspects of daily life. Work, leisure, entertainment, and education are merging and becoming intertwined. How to describe what we do for a living when machines are increasingly doing it for us? How to describe a product when that product is increasingly intangible and, in some ways, nonconsumable? How to prepare for a future without jobs as we currently know them?

This chapter concludes the discussion of work and working. However, the dialogue, debate, and discussion will continue in Canada and elsewhere. It will be the main item on this nation's agenda for the remainder of this decade.

Chapter 5

Privacy: The Concerns

> When technology reaches a certain level, people begin to feel like criminals. Someone is after you, the computers maybe, the machine-police. You can't escape investigation. The facts about you and your whole existence have been collected or are being collected. Banks, insurance companies, credit organizations, tax examiners, passport offices, reporting services, police agencies, intelligence gatherers . . . . Devices make us pliant. If they issue a print-out saying we're guilty, then we're guilty. But it goes even deeper, doesn't it? It's the presence alone, the very fact, the superabundance of technology, that makes us feel we're committing crimes.[1]

Privacy is a growing issue in relation to information technologies. Numerous surveys, books, and scholarly articles have dealt with the topic. Although there is no broadly shared definition of privacy there is, nevertheless, a high degree of public concern. For example, a recent study commissioned by the Government of Ontario Task Force on Microelectronics reported on a poll of public opinion on the social effects of microelectronics.[2] Respondents were given a list of 13 issues related to microelectronics and were asked to indicate the five most important. The issue chosen most often (by 63 per cent of respondents) was privacy and confidentiality of personal information. The next three most important issues were accuracy of billing, control of information, and job security. The entire range of responses is reproduced in Table 5.1 to indicate the degree to which respondents indicated privacy and confidentiality to be the number one issue.

Table 5.1. Ontario Residents' Judgements of the Five Most Important Social Issues Related to Microelectronics[3]

Issue	Percentage of Respondents Who Judge Issue as Important
Privacy and confidentiality	63
Accuracy of billing	46
Control of information	45
Job security	44
Job pay	38
Job safety	38
Computer crime	34
Cost of home equipment	30
Information about what organizations are doing	29
Job stress	28
Job interest	27
Job challenge	25
Complexity of home equipment	18

A more recent survey was conducted as part of a report to the Ontario Ministry of Transportation and Communications.[4] The survey was conducted to explore Canadian attitudes toward privacy, with particular reference to potential problems of privacy resulting from two-way cable television services. Privacy was defined as "the ability to control the collection and use of information about oneself."

The findings of the report showed that concern for privacy is very high. In a somewhat limited sample of 210 homes in London, Ontario, personal privacy was rated as more important than stopping the spread of nuclear weapons. The right to privacy was rated as more important than rights of freedom of speech, freedom of the press, and sexual equality. Moreover, fully 68 per cent of the people interviewed believe Canadians have less privacy than they did 10 years ago, while 62 per cent indicated that they are concerned about threats to their personal privacy.[5]

A Harris poll in the United States produced similar results. It showed that 77 per cent of the people polled were worried about the threats that computers posed to their privacy. According to Louis Harris, the fears about personal privacy have grown substantially in the last five years with the increasing use of computers to maintain credit card accounts, monitor loans, and administer credit.[6]

Similar polls in the United States, Sweden, and the United Kingdom have yielded similar results. The fear appears to be that the new information technologies will somehow affect the privacy of the individual. This fear is perhaps best expressed in the following excerpt:

> The computer, with its insatiable appetite for information, its image of infallibility, its inability to forget anything that has been put into it, may become the heart of a surveillance system that will turn society into a transparent world in which our home, our finances, our associations, our mental and physical condition are laid bare to the most casual observer.[7]

Information Technology Changes the Context in which Canadians Live

The context in which Canadians live is changing because of the widespread use of information technology. There are three main concerns that, when linked, make up the privacy issue:

Concern 1: Because of microelectronics and increasingly inexpensive computing capability and memory, an information infrastructure is being put into place very rapidly. All vital statistics can or will be stored in a computer somewhere. These would include details of transactions of all types as well as legal, medical, and educational documentation. With computer transactions, people leave an electronic trail that can be stored, cheaply, in perpetuity.

Concern 2: With computer networks and increasingly standardized communication protocols, it is technically feasible and increasingly inexpensive to interconnect many databases. The information in them can be shared to prepare information profiles on individuals quickly and cheaply. This is one subset of a broader technique known as "data-linkage." A computer can be programmed to scan all information inside a given set of records and to link data by any item of information contained in the record. Most large computers used by governments and industry have the capacity to perform data-linkage.

> It is just as easy to locate those who were born between 1930 and 1940 and who are doctors, or to link the social insurance numbers of those who are identified as plumbers in the first set and who appear in the second set. The limitations or combinations depend on imagination and the laws of mathematical logic. Suddenly, one may reconsider Orwell's predictions for 1984 or whether the computer, Hal, in *2001: A Space Odyssey* represents more than merely an author's monstrous invention.[8]

Concern 3: In Canada, at least, no integrated set of laws exists to protect the individual in this area. Except as noted elsewhere in this study, there is no serious prohibition on the sharing of information about people.

The electronic context within which Canadians live is becoming ever more comprehensive. It is becoming easier and easier to create an electronic profile of any Canadian. Habits, attitudes, political preferences, medical history, and so on can all be put together to create an individual profile. This in itself is a serious threat to individual privacy. Even worse, the data in one or more of the data banks may have been incorrectly entered or may have changed with the passage of time, thereby giving an incorrect profile of an individual. In most cases the individual does not know what information is retained and rarely if ever is given the opportunity to verify the accuracy of the information.

Paper files differ from electronic files in a fundamental way. The paper file cannot easily be altered since any tampering with the written or printed word can in most cases be detected. The electronic file on the other hand is readily corrupted. The electrical pulses in which the information is stored can be modified without any trace of the modification. It may be sufficient to change no more than one bit in a long string of bits to change the stored information significantly.

> In the case of a written document, if anybody alters it an expert can tell that the document has been altered. The document may be merely expunged, as they did in the Middle Ages, or have a line drawn through it, as later, or the ink may be scratched out with a knife and something overwritten; but there is always a trace left. A particular dot, or bit, as it is sometimes called, can be written and overwritten many times without leaving a trace. So it is impossible to find out whether something has been overwritten or not, and it is necessary to have a security system to make sure it is not.[9]

"Smart" Technology Makes People More Vulnerable

The widespread use of computer technology with its capacity to remember has an almost humorous side to it. It was recently noted that the computer that controlled the 1981 Cadillac's V-8-6-4 variable displacement engine could also be used as an electronic spy. The onboard computer recorded every time a driver exceeded 80 miles per hour and when certain systems malfunctioned. Cadillac says the information has never been used in any warranty disputes. Nevertheless the Orwellian implications are both obvious and ominous.[10]

Privacy becomes an issue not only in the direct storage, transmission, and manipulation of data but also in the area of surveillance. Patterns of data can be analysed to determine whether an individual has broken the law — or is about to. In a personal exchange with a leading network analyst in the United States, it was revealed that until 1980, the major airline companies in the United States routinely transferred computer tapes of passenger activity to the Federal Bureau of Investigations (FBI). Presumably this action would reveal whether and to what extent individuals involved in organized crime were travelling to certain destinations and illegally transferring funds to offshore destinations. Other stories on surveillance appear in the press from time to time. It has been alleged that the super-secret National Security Agency of the United States has computer equipment capable of monitoring overseas telephone calls. The equipment is supposed to search calls for key words. Thus if someone mentioned certain words such as bomb, terrorist, extortion, or any one of a number of coded words, the entire conversation would be recorded and stored. Attempts would then be made to trace the call to determine the identity of the speakers.

A more common example of the surveillance made possible by microelectronics is the use of cameras in stores, banks, and shopping malls — in fact in any public place. The arrest of the alleged perpetrator of the Tylenol poisonings in Chicago in 1982 highlighted the use of these cameras. One of the drugstores in which the poisoned Tylenol was placed had a surveillance camera and kept its recordings on file for some months. Police analysts were able to determine that the alleged criminal, James Lewis, was in that store at about the time the first poisonings were discovered.

Other techniques for surveillance are too numerous to mention but all arise from the computer's inherent ability to remember. The use of bar codes such as the Universal Product Code allows for tremendous increases in efficiency and productivity in all aspects of the handling and distribution of products. A bar code is that familiar little patch of stripes that adorns billions of supermarket items, from cans of cat food to boxes of breakfast cereal.

Easily read and decoded by computers, the stripes are finding new uses in unexpected places — not just in supermarkets. They are used to track inventory on aircraft carriers, blood in blood banks, and applications in the United States Patent Office. They identify the users of libraries and cafeterias, hospital patients, and athletes. Sales staff are using catalogues with bar codes printed beside each product for recording orders, and at least one airline is using the stripes to sort baggage.

Bar codes make the handling of all products more efficient since they make the use of computers more efficient. Most computers do not read natural languages (such as English), and the ones that do are expensive and not very good at their task. Highly trained data-entry operators supply most information to computers by typing it in at keyboards, but people are slow and error-prone by computer standards. Computers equipped with special scanning devices can read bar codes quickly and accurately, a process the computer industry calls automatic data entry. In effect, bar codes are to computers what Braille letters are to the blind.

The use of bar codes in libraries increases the efficiency of the entire library system. Books can be checked out and in much more quickly than with the older, manual system. Bar codes also allow for more effective management of a library's inventory. However, with greater efficiency, privacy also can surface as an issue. It is simple to press a few keys on a terminal keyboard and thus find out the reading tastes of a library user. In an article on privacy in the *Globe and Mail* one individual was quoted as saying:

> The other day I went to the library and had to get a new card, one with a bar code for optical scanning. Now there can be a record of my reading habits — you sort of feel you don't want people to know everything about you.[11]

The amount of information being stored electronically is growing daily. The United States government has collected four billion separate records on the citizens of that country. This amounts to 17 items for each man, woman, and child. All this information can be quickly and cheaply obtained.[12] By 1985, International Business Machines (IBM) predicts that the amount of data stored on-line in electronic files will jump to seven times the 1.7 trillion characters that are stored today.[13]

Databases May Not Be Secure

The challenge for corporate and government bureaucracies is to ensure that data are available to those who need it. Balanced against the need for accessibility is the equally important need for security.

To increase the security of a computer system means increasing the cost of operation, which, at the limit, could offset the productivity gains earned from installing the computer in the first place. All computer systems are vulnerable to criminal activity. Many are easy to break into and once penetrated, can be easily manipulated. This is reflected by the increase in computer crime.

White-collar thieves have misused computers to embezzle funds, pilfer timesharing services and programs, eavesdrop on the bids of business competitors, divert inventory, disclose tax and banking records, copy valuable mailing lists, monitor private medical and pharmaceutical records, forge payroll checks, reduce or eliminate premiums on insurance and other installment-type payments, and alter transcripts at colleges and universities.[14]

Several years ago the then president of Datacrown, Richard G. Taylor, made a presentation to a computer crime prevention conference sponsored by the Ontario Provincial Police[15] in which he noted that "there is no such thing as an absolutely secure computer system."

Taylor described his own company's system of security, which, he said, is designed to promote a security-conscious atmosphere among employees and clients. The system uses a variety of security measures to protect data, equipment and operations, software, communications, and company buildings.

The company's procedures include methods for hiring and firing personnel, personal identification badges, restricted access to data processing areas, as well as physical protection such as locked doors opened only by a code, various fire warning and prevention facilities, and an uninterruptible power supply system. In addition, the data are protected by elaborate password systems as well as encryption scrambling techniques and several options for tape backup protection.

Even with all the security, Taylor described how he once discovered that an employee in a client company was planning to form his own firm and steal data from his former employer's files held at Datacrown. "We looked into what charges could be laid, but once it became clear that there was no significant charge we could bring in, we had to back off," he said. "This is a serious problem. It means that computer technology has outrun the capability of the law to cover potential crimes."

According to Taylor, the two limiting factors on computer security systems are people and money. "How far can one go in security procedures without infringing on basic human rights and freedoms? Does an organization have the right to search an employee physically if it is suspected that he or she is attempting to take sensitive documentation or other company property off the premises? How far can a company comfortably go in conducting surveillance on the living habits of an individual employee?"

Databases in major corporations are not secure. Even the most advanced encryption techniques (to code and scramble computer data) can be broken. If the elaborate encryption codes used by such super-secret agencies as the United States National Security Agency and the Central Intelligence Agency can be broken, then how do average citizens react when government bureaucrats try to assure them that their personal data are confidential and secure in the computer of the bureaucracy?[16]

We Can Be "Known" by Many Who Really Don't "Know" Us

Over the last 20 years, the communications revolution has led to the accessibility of vast amounts of personal information in corporate and government computers. The largely unregulated flow of this information between different data banks results in people having little or no idea of who knows what about their personal lives. Thus public and private institutions accumulate huge amounts of information about — and power over — the individual.

Computers have allowed consumers to extend lines of credit around the world. But a system that permits goods to be bought on credit requires that shopkeepers have an efficient, quick method of checking customers' ability to pay before they leave the store. Computer-linked credit bureaus have met this need by creating an extensive data pool.

The typical credit report contains "a person's name and address, family status, place of employment, approximate salary, credit limit, charge accounts, payment amounts and even, in the case of insurance company files, medical and hospital records and 'moral hazards' — extramarital affairs, homosexuality, heavy drinking or other social observations which could affect the risk."[17]

With such a store of information, the potential for abuse is obvious. First, an inaccurate report, the result of either sloppiness or malice, could destroy a person's chance to obtain a loan, mortgage, or even a job. The error may remain in a data bank for years, with the victim never suspecting anything.

Easy access to personal files by various organizations presents another threat to personal freedom. The Associated Credit Bureaus of Canada exchange credit information with 3000 businesses in Montréal alone. Thus at least 3000 people in Montréal have at their command detailed information on the financial affairs of millions of other people.

Most people, whether they realize it or not, are listed in the computers of a credit agency somewhere. A single database located in a suburb of Los Angeles contains summary credit fact sheets on 86 million Americans. This information can be obtained within seconds by thousands of stores in the United States. The credit bureau, a subsidiary of the aerospace company TRW, sells about 35 million credit reports annually to its 24 000 subscribers.[18]

Responding to government pressure in the late 1960s, the Associated Credit Bureaus of America began to allow people access to their own files. Their Canadian counterparts maintain the same policy. In theory, the availability of files for inspection should greatly increase their reliability but, of course, this method of personal verification will work only if people start checking their files regularly. Bureaus release files only if they want to; no law compels them to do so.

In the case of TRW, about 350 000 people a year formally complain to the company's public relations department about the accuracy of TRW's computer records. Each year as many as 100 000 of these complaints result in TRW changing the information in the computers. The question arises: how many incorrect entries go unnoticed and therefore affect the individual who wants to secure a mortgage or other type of credit?[19]

Improvements in information storage and transmission afforded by the computer age have allowed governments to assume an expanded role in people's lives. These new capabilities have permitted the establishment of such beneficial services as universal unemployment insurance and medicare. In return, individuals have had to surrender a certain degree of privacy by providing personal information for the computers of these services.

Many people find it hard to object to making personal disclosures to the government, since they are assured that the information, once in the government's hands, can only benefit them.

The dangers inherent in widespread data collection have emerged. Electronic theft of government files is becoming a distinct possibility. Although computer security may be relatively high, the centralization of great amounts of information in one database increases the incentive to break into it. The 1500 Canadian government databases that contain personal information about Canadians are by no means invulnerable. This fact was amply demonstrated in the spring of 1980 when several New York high school students used normal phone lines to gain access to some Canadian government data banks.

A more serious break-in occurred in August 1983 when a member of a group of Milwaukee, Wisconsin, computer hobbyists broke into a computer at the Los Alamos National Laboratory. The computer at Los Alamos was one that was considered "not sensitive" since it was being used for electronic mail. Equally startling was a report that a member of the same group of hobbyists was able to use his Apple computer to break into and access patient records at the Memorial Sloan-Kettering Cancer Center in New York.[20]

A more widespread and insidious problem is the fact that information released by a person to one government agency often ends up in the data banks of other government departments or private corporations, without the knowledge or permission of that person.

An example of the ease with which computers exchange information occurred in Winnipeg several years ago, when a high school student incorrectly coded his Scholastic Aptitude Test (SAT) form, causing the computer to record that he studied in Kabul, Afghanistan. Several weeks later, when Canadians were being evacuated from Afghanistan during the Moslem uprisings, the federal government called the school to see whether one of its students was currently studying in Kabul. Apparently, the Canadian government had gained access to the SAT computer files in the United States during its search for Canadians in Afghanistan.[21]

Indeed, the 1972 Canadian Task Force on Privacy and Computers, after studying the use of personal data files throughout the nation, found that there was much more interchange of data among systems and that there were many more inaccuracies in the files than the public realized. Although the task force found that few individuals had actually experienced any intrusion on their personal privacy through the use or misuse of computers, it warned that the rapidly rising volume of computerized personal data and the equally rapidly rising public expectation of a right to deeper and more secure privacy could converge, creating a problem of "major proportions."[22]

The linkage of computers and telecommunications systems throughout the western world has created an impressive police network:

> The networking of communications permits a local law officer to learn in minutes if a person detained for a traffic violation is wanted

> for other criminal activity by police in other jurisdictions. Communications with a central information centre can provide the officer with nearly instantaneous information on whether a suspect is driving a stolen car. Fingerprinting, a major means of identification, can be computerized, and that process is proceeding, so that identification by such a print can occur within minutes of a request, no matter where the request comes from.[23]

The fact that a record is stored on a computer does not mean that it is accurate. A study carried out by the Office of Technology Assessment of the United States Congress found that only half of the criminal history records sent by the FBI to local law enforcement agencies were "complete, accurate and unambiguous." The potential benefits of a national computerized criminal data system must be balanced against the errors that occur because of incomplete or inaccurate information entered into the database, or because of the passage of time.[24]

Electronic Transactions Can Increase Knowledge of the Individual

The use of the interactive systems in the home (either via the television cable or telephone systems) represents yet another potential privacy concern. A number of issues have been raised in this chapter, and the daily press contains many instances of how the use of electronic funds transfer systems from the home or teleshopping can help to build consumer profiles. Perhaps the most widely noted concern is the extent to which some two-way systems allow viewers' tastes to be identified.

For example, the Qube[25] system in Columbus, Ohio, operates on a pay-per-program basis. Thus the company maintains files on what types of programs their subscribers are viewing. Although it is most unlikely that people should feel threatened if they watch adult or pornographic movies, there exists the uneasy feeling that someone "out there" knows what they are choosing to watch on television in the privacy of their homes.

The question could arise that while the cable company could not or should not care what their subscribers view (in much the same way that telephone companies are indifferent to material passing over their lines), a police agency or court might have occasion to demand the files of the cable company.

In fact, a case of this sort has already affected the Qube system. When a local movie house operator was arrested for showing two obscene adult movies, the defence attorney tried to prove that the films did not violate community standards of obscenity by demonstrating the widespread local appeal of one of the films, which had been shown over the Qube system. Faced with a subpoena, Qube did reveal the *general* viewing statistics for the film in question and for the patterns of use of the adult channel. (Court testimony revealed that 10 655 television sets were tuned to the showing of *Taxi Girls* and other adult films. As many as 25 per cent of Qube viewers watch the adult entertainment channel.) Does such characterization of a community or neighbourhood constitute a loss of privacy for its residents?

Qube said it would fight to prevent court access to *individual* viewing records all the way to the United States Supreme Court, but it is not clear whether other interactive home media corporations would resist such attempts to acquire individual records. The legal and regulatory provisions governing court access to individual records are in a very uncertain state.[26]

As the diversity of services available through home-based interactive systems grows, the privacy dangers multiply as well. Electronic funds transfer (EFT) has a huge potential for abuse. The information that shuttles through an EFT system is truly explosive: it can reveal the pattern of a person's movement in a day, a pattern of purchases, habits of expenditure, preferred products or merchants, preferred charitable or religious causes, travel habits, or even transactions that members of a family are trying to conceal from one another. EFT could be used by the police in monitoring and cracking down on corrupt officials and organized crime. But consider the dangers of the police monitoring the financial behaviour of innocent citizens. The known historical abuse of wiretap surveillance provides little comfort that citizens' privacy would be respected.

Questions need to be asked: Who is to be responsible for the safekeeping and security of this information? Will cable operators, banks, government agencies, or merchants be legally obliged to control the flow of this very personal information; if so, under what terms? And how can those who handle information be induced to respect certain standards of privacy?

The move into the information society also raises some important general questions. Who will provide information and what will be the nature of the information provided? Can we resolve the tension between the individual's need for privacy and society's desire for information? What are people entitled to know about the information that is retained about them? To whom are these systems accountable and what assurances are there of compliance with whatever codes are established? Finally, how much information about individuals is really needed in order for society to function, and how will we make that decision?

Chapter 6

Privacy: Some Solutions

Legislation to Protect Privacy: A Good First Step

The widespread introduction and use of computers in western society, which began in the early 1960s, has led to continuing preoccupation with its implications for personal privacy. During the 1970s many European nations, especially Sweden, West Germany, and France, established data protection agencies to regulate the storage of personal information in the public and private sectors. The process is continuing in western Europe during the 1980s. Canada and the United States have not done as much to establish bureaucracies charged with the general protection of personal privacy at national levels. In 1982 Quebec announced legislation to implement the 1981 report of the Paré Commission, which includes a European-style commission for data protection. At the federal level in the United States, there is continuing debate as to whether Congress can continue to protect personal privacy on a sector-by-sector basis. The sheer burden of fashioning specific new legislation for such areas as medical records may force the United States to create a type of data protection organization for federal purposes.[1]

The European countries are currently in a better position to respond to personal privacy issues raised by new information technology than are Canada and the United States. Most emerging problems in Sweden, West Germany, and France, for example, can be readily channelled through existing data protection agencies for review, evaluation, and recommendations for regulation. Such agencies have either licensing or advisory functions for all new personal information systems. By contrast, the protection of the legal right to personal privacy is hardly recognized in Canadian law.

Action to protect personal information in a time of accelerated technological change is just beginning. Most often, legislation to restrict privacy invasion is the route chosen by the industrial western nations. Equally important, potentially, are legal court actions, industrial and professional self-regulation, public awareness campaigns, as well as community and individual action.

Legislative Action: Canada's Initial Efforts

Canadian efforts to restrict privacy invasion began in earnest with the passage and implementation of privacy access legislation as part of the Canadian Human Rights Act in 1978.[2] These provisions granted individuals access to information about themselves contained in certain federal government records. The provisions also gave individuals the right, in some instances, to correct personal information held by the federal government.

More recently, in the 1982-83 period, these provisions were refashioned as part of the access to public records policy, entitled the Privacy Act. The main changes to the 1978 legislation were:

- inclusion of judicial appeal for persons denied access to their records;
- extension of access to all personal information held by the federal government, and not simply to information used for administrative purposes;
- listing of all third parties who have access to personal information;
- strengthening of the office of the privacy commissioner.

The Privacy Act, which applies to some (but not all) federal government agencies, gives individuals limited access to personal information records and limited rights to correct such information. Complaints can be taken to the privacy commissioner and some complaints can then be appealed to the Federal Court of Canada. The Privacy Act provides for the continued publication of an annual index of federal personal information records.

Other federal legislative measures designed to protect personal privacy include:

- the Protection of Privacy Act, 1974, an act designed to incorporate into the criminal code laws that deal with wiretapping;
- the Income Tax Act 1976-77, chapter 33, whose section 241 contains limits on conveyance of personal tax information;
- the Statistics Act 1970-71, chapter 15, whose sections 6 and 16 prohibit disclosure of personal statistical information.

At the provincial level, no privacy access acts have yet been implemented, although Quebec is likely to proclaim legislation in 1984 and Ontario's Royal Commission on privacy, the Williams Commission, has recommended privacy access legislation.[3] Again, there are some related provincial legislative measures, such as Ontario's fair credit reporting act, which allows access to personal credit records and some correction rights.

Although Anglo-Canadian common law does not explicitly recognize a right to privacy, the provinces of Manitoba, Saskatchewan, and British Columbia have created privacy acts to protect the individual in certain circumstances. The legislation deals with unauthorized use of personal letters, diaries, and other personal documents. Also suggested is an intention to control unwarranted invasions of physical privacy by way of eavesdropping, and direct or electronic surveillance. However, none of the three privacy acts deals expressly with the inappropriate or unauthorized use of personal information that has been given voluntarily to another person or institution and integrated in an information bank.[4]

As Professor David Flaherty of the University of Western Ontario has pointed out in his international studies on privacy legislation, the North American approach differs considerably from western European initiatives in countries such as Sweden, West Germany, and France.[5] Instead of focusing primarily on access to government records, the Europeans chose to apply their legislation to the private sector as well. To prevent abuse of personal information, data protection commissions license those who manage personal data banks.

The United States has partly moved in this direction. It has extended its 1974 legislation governing access to federal government records by a 1979 act that allows for access to the records of private sector financial institutions. As noted above, in the early 1980s the Quebec Paré Commission and the Ontario Williams Commission recommended a European-style commission for personal data protection.

A Canadian data protection commission may turn out to be a necessity as various interest groups call for privacy legislation to be applied to most of the private sector (for instance, to grant access to medical records); to include protection of personal information crossing national boundaries; and to recognize that better public participation is possible via regulatory licensing hearings in implementing privacy protection.

This is not to say that the European countries with privacy legislation can respond to all the issues of privacy invasion raised by the new information technology. However, European legislation does go farther than that of Canada or the United States.

One student of the Canadian privacy scene, Ken Rubin,[6] a consumer advocate and civil libertarian, would like to strengthen the 1982 legislation. His criticisms of the new Privacy Act's inadequacies include:

- its primarily "after the fact" approach and confinement to certain government records: Rubin advocates a "before the fact" comprehensive privacy protection act;
- its weakness in protecting how personal information may be collected, in the manner of obtaining individual consent, and on the question of ownership of personal information;
- the fact that it enables too many third parties to have access to too much personal information, while allowing far too many personal information banks to be inaccessible to the individuals to whom the data pertain;
- its weakness in ensuring that personal information collected for one purpose will not be linked to other personal information, be it

through the means of social insurance numbers or other mechanisms.

Rubin favours the European system of licensing and regulation, but goes beyond privacy access questions by proposing a comprehensive bill that would take a restrictive stance on privacy issues such as wiretapping or mail opening, and the use of lie detectors, computer interceptions and writs of assistance. Such a bill would also regulate transborder data flows, electronic monitoring of individual work performance, and the marketing uses of subscriber listings and profiles created by interactive videotext networks and similar systems.

Still, most observers believe that existing Canadian legislation is off to a good start with over 10 000 Canadians each year making use of the 1978 privacy access provisions. The 1982 Privacy Act calls for a 1986-87 parliamentary review of privacy legislation. Already amendments that would strengthen privacy protection are being suggested for the Criminal Code. These are the recently announced suggestions to prevent and deal with some types of computer crime, including illegal access to and use of personal data.

Litigation and Court Action: A Promising Approach

There are those who believe legal precedents in the next few years may go a long way to help protect personal privacy. Until now, the Canadian courts have not recognized any tort of, or legal right to, privacy; and there are few legal actions on privacy invasion grounds that involve theft of personal information.

Litigation and legal precedent have been advocated by three different sources. One, the Williams Commission in Ontario, recommended in its final report (chapter 35) the civil right to sue if Ontario misuses private data; where damaging personal information is released, monetary damages could be awarded.

On another front, Inger Hansen, former privacy commissioner (now access to information commissioner) has advocated, in her report to Parliament, the need to amend the Criminal Code so as to make theft of personal information a criminal act. The Criminal Code inadequately deals with this kind of "theft" because it is more concerned with matters relating to the stealing of personal property, as opposed to personal information.

A third source, as yet largely untried, advocates legal action under the new Canadian Charter of Rights and Freedoms, particularly on the grounds of "security of person" in the clause "life, liberty and security of person." This section of the charter has already begun to be used to test the courts' views on other issues such as abortion. The use of constitutional law, along with civil and criminal remedies, may well advance the privacy protection cause.

Nonetheless, there are those who see court action as costly and time-consuming and not necessarily as a tool to deter institutions or individuals from privacy invasion. There is, however, little argument that a powerful tool will have been added to the arsenal of privacy protection if the notion of individual control of personal information is upheld in the courts, or it becomes an offence to alter, use, process, manipulate, transmit, or destroy personal information unless authorized by the individual or as stipulated in clearly defined laws.

Industrial and Professional Self-Regulation

Court orders and legislation cannot alone impose a new understanding of the importance of protection of personal information. Private or public sector enterprises, both profit making and nonprofit making, could be potent forces in privacy protection, through voluntary codes of privacy conduct, management decree or labour bargaining, or redefinition of standards by professional and occupational groups.

Some of the leading multinationals, such as International Business Machines (IBM), have already adopted employee guidelines in detailed codes for privacy protection. Other companies, such as American Express, have created privacy policies for their card holders. Some Canadian insurance companies, such as Aetna Casualty Company of Canada, London Life, and the Excelsior Life Insurance Company, have engaged in self-regulation of individual information and have published detailed privacy codes. In 1982, the Bank of Montreal published a code of confidentiality and privacy.[7] Some unions, like the Canadian Union of Postal Workers, have fought for privacy protection for data on individual work performance collected by electronic means as part of their collective bargaining agreements. Professional associations, such as the Canadian Information Processing Society, have also begun to discuss privacy standards.

Agencies in the public sector, too, have developed privacy policies. For example, a special advisory committee on personal data systems to the Secretary of the United States Department of Health, Education and Welfare has proposed a code of fair information practices, which states that:

- There must be no personal record-keeping system whose very existence is secret.
- There must be a way for individuals to find out what information about them is on record and how it is used.

- There must be a way for individuals to correct or amend a record of identifiable personal information.
- There must be a way for individuals to prevent personal information that was obtained for one purpose from being used, or made available for use, for other purposes without their consent.
- Any organization creating, maintaining, using, or disseminating records of identifiable personal data must guarantee the reliability of the data for their intended use and must take precautions to prevent abuse.[8]

Again, the approach has its limits. Not all bodies will adopt such codes of behaviour or adhere to them in practice. Indeed, self-regulation at times can be a smoke screen for a do-nothing approach or a weak stance on privacy protection.[9]

Media and Educational Institutions

Perhaps the best approach lies in the area of increasing public sensitivity to the issue of privacy. This works only if there is awareness and publicity. Unfortunately, Canadian media and educational institutions are not currently at the forefront of the privacy issue.

Little is done in the schools to prepare students to deal with privacy invasion or to promote protection of their identities. Few courses on the subject are offered even at the college or university level. Indeed, it has been school children in both Milwaukee and New York who have most dramatically demonstrated how easy it is to invade privacy with modern technology.

The media too, with a few exceptions, have been reluctant to do in-depth reporting on privacy issues. On the contrary, recent court cases attest to the media's willingness and desire to gain more access to personal information, be it through the juvenile courts or elsewhere. The media are caught between reporting on private affairs and promoting awareness of the dangers of privacy invasions. Their dilemma is captured in the Ontario Press Council's statements, including its 1974 pamphlet, *To Name or Not to Name.*

It is clear that further attention will have to be given to the ways in which schools and media can contribute to privacy protection.

Community-Based and Individual Action

Often forgotten and overlooked is what people can do themselves, at the community level, either through groups or as individuals. Ken Rubin lists a variety of individual and community actions that can help privacy protection.[10] Examples of individual action include:

- giving out only necessary information;
- avoiding the use of credit cards;
- writing on personal information forms that the information given is the individual's property and that its use should be solely for the stated purpose;
- reading up on the subject of information privacy and asking for courses to be taught on the subject;
- writing letters to newspaper editors, politicians, or to the privacy commissioner;
- making a submission to one of the relevant inquiries holding hearings;
- seeking out media publicity on information privacy abuses;
- initiating court action for breach of confidence;
- asking which law says an individual has to give information in particular situations.

Examples of group action include:

- joining or forming a local civil liberties committee;
- holding public meetings;
- conducting petition campaigns;
- producing a privacy newsletter;
- seeking support from other groups;
- presenting briefs and lobbying for changes;
- investigating local abuses and publishing the results of these investigations;
- undertaking test court cases on specific exemptions and unauthorized third party access;
- pressing for information privacy provisions in collective bargaining agreements;
- withdrawing from commercial or financial institutions using unfair information practices;
- boycotting businesses that are aggressively intruding in customers' or employees' personal affairs.

Rubin argues that privacy invasion in some form affects everyone, and that citizens must begin to ask governments and the private sector why, for how long, and for what purpose personal information is needed. Rubin contends that privacy policies require open public debate and that privacy invasion will become a national social crisis and a major problem in future citizen-government relationships if a laissez-faire approach predominates. Healthy scepticism can be channelled into positive community and individual action, which in turn will allow individuals to assert control over personal information.

Combining Different Strategies: An Agenda for Privacy Protection

Individual privacy will be protected only through changes in attitude and a multitude of consciously applied strategies at all levels of society. Both individual and collective action is needed to combat privacy invasion. Government intervention to restrict privacy invasion cannot in itself succeed without the insistence of the public and parallel action in the workplace and in the community.

One person may perform many roles to fight for privacy protection. For instance, a computer specialist, instead of shrinking into a comfortable job, may be at the forefront of developing a professional code of privacy ethics, may help convince his or her company to do likewise, and at the same time conduct a public awareness campaign through a professional group. That same individual can join and be active in a civil liberties group whose activities might include taking on cases of privacy abuse and pressing for more progressive privacy protection legislation.

The attitude "privacy invasion can only happen to my neighbour" is an illusion. Preventive actions rather than remedial makeshift solutions are needed to protect privacy. Credible and tough action on various fronts, while they will never provide absolute privacy protection, will go a long way toward preventing privacy abuse.

It can safely be assumed that increasingly imaginative legislative and voluntary approaches will be taken to protect the privacy of Canadians. However, in the view of this writer, these actions will not solve the privacy problem, since it is rooted in a psychological issue that does not lend itself to easy solutions. The problem lies in the area of personal autonomy and possible loss of control over the various data and descriptions that define the individual.

Chapter 7

The Psychological Dimension to the Privacy Issue

Most of the literature on privacy refers to threats to privacy but does not define what is being threatened. The issue is a difficult one to discuss, in part because privacy is such an elusive concept. It is fairly easy to know when the privacy of a person or group of persons has been "invaded"; it is more difficult to judge when the amount of privacy desired by a person is just right. In some respects, the right amount of privacy is like the right amount of silence. People who complain about a neighbour's lawn mower or barking dog do not want absolute silence. Rather, they seem to want some control over the noise level in their environment. The amount of noise tolerated is related to the time of day and location. During rush hour at a crowded downtown intersection, everyone expects traffic noise and blaring radios. At midnight in a suburban area such a level of noise would be unacceptable. People will tolerate noise levels in the workplace that they would not tolerate at home. By contrast, the sound of a teenager's favourite record played at full volume in the home may be tolerated (for a while) whereas comparable levels of sound originating from the next-door neighbour will not be tolerated. The degree of tolerance appears to be quite personal and very much related to the context of the disturbance and the degree to which individuals feel in control of their environment.

Like noise, privacy is difficult to define. It is the aspect of one's identity that is personal, not publicly known. It contains information about the self that is confidential, that belongs to, and is the sole concern of, the individual. It is closely related to the individual's personality and perceived or preferred concept of the self.

The Government of Ontario report, the Williams Commission, *Public Government and Private People*, accepts privacy as a basic human need:

> Although the "privacy problem" and the "right to privacy" are relatively recent arrivals on the agenda of public discussion in the Western industrialized democracies, the concept of personal privacy is of more ancient lineage. Indeed, there is considerable support for the view that the need of human beings for personal privacy is a universal, a common element in the human experience. It was evidenced in the social conditions of ancient Greece. It is manifested in the customs and communal life of primitive tribes. It is, in short, a fundamental and enduring human value. Some writers have suggested that privacy mechanisms are observable in the behaviour patterns of the animal world, and that perhaps a biological root is to be found at

the bottom of this rather substantial behavioural tree. Perceptions of the nature of and the need for privacy will vary among societal or cultural groups, and will change from one historical period to the next. Within the same society, these perceptions will vary with individuals and evolve with changing social conditions. Nonetheless, the preservation of some measure of privacy or private life appears to be an essential feature of human existence.[1]

The Issue Is Personal Autonomy

W. Lambert Gardiner, in a background paper prepared for the Science Council, argues that the threat posed by personal data banks and the widespread introduction of computers is not invasion of privacy but erosion of autonomy.[2] For Gardiner, the threat to individual autonomy is the reason privacy has become such an emotionally charged but poorly explained issue.

Each of us defines for himself or herself the self or core personality — that is the essence of being an individual. The core self can be thought of as a series of concentric circles or zones of privacy. The innermost circle holds a person's closest feelings and secrets — those hopes, fears, and spiritual feelings that are beyond sharing with anyone unless that person comes under such stress that he or she must pour out these ultimate feelings and secrets to gain emotional relief. The next circle is open to the person's friends. The series continues to the outer circles of casual conversation and behaviour open to all observers.[3]

The innermost zone of privacy is important for individual development. In that zone people can think their own thoughts, have their own secrets, develop their own fantasies, and, in general, reveal only what they want to the outside world. "The right of privacy, in short, establishes an area excluded from the collective life, not governed by the rules of collective living."[4]

The ability to grow and develop a sense of self vis-a-vis society becomes an important aspect of the psychological development of the individual. Sidney M. Jourard, a psychologist, notes:

> The experience of psychotherapists and students of personality growth has shown that people maintain themselves in physical health and in psychological and spiritual wellbeing when they have a "private place," some locus that is inviolable by others except at the person's express invitation . . . .There he can do or be as he likes and feels. He can utter, express, and act in ways that disclose his being-for-himself. And he does not need to fear external sanctions. Nor does he feel guilt for the discrepancy between the way he appears in public and the way he *is* in private.[5]

Personal autonomy depends on the individual's ability to control how and under what conditions the private self is revealed to a public world. A threat to this autonomy is, for Gardiner, at the heart of the privacy issue.

According to Gardiner, there are two ways in which the individual can exercise his or her personal autonomy in projecting a self-image to the rest of society: self-disclosure and impression management. Self-disclosure is the open and honest presentation of one's self; impression management is the creation by a person of some desired impression on other people. An individual might choose self-disclosure in intimate situations, such as in marriage, in dealing with therapists or confessors, or even in speaking to a total stranger on a plane or bus where anonymity, and therefore privacy, is assured. The individual is far more likely to use impression management on the job, when seeking employment, preparing a curriculum vitae, going out on a first date, or in deciding what clothes to wear to an important meeting.

In a world in which total self-disclosure had no negative consequences, personal data banks would offer no threat. The only concern would be that the information be accurate and not misrepresent the individual. In the real world, however, a person may find it expedient to be less open with some people (employers, business associates) than with others (close friends, therapists). It all depends on how much the individual has to gain or lose. The individual is the only one who can decide how much of the self to make public in a particular situation.

For Gardiner, a person's ability to control the amount of personal information made known to others is the crucial aspect of autonomy. The more that can be known about a person by tapping data banks, the less that person's autonomy.

The important consideration is not whether people use self-disclosure or impression management, but whether it is possible for them to choose to use one or the other whenever they wish. That is, the issue is not privacy, but autonomy, the extent to which personal choice is possible. Thus, the real threat of personal data banks is not invasion of privacy but erosion of autonomy. As Allan Westin notes in *Privacy and Freedom,*

> The most serious threat to the individual's autonomy is the possibility that someone may penetrate the inner zone and learn his ultimate secrets....This deliberate penetration of the individual's protective shell, his psychological armor, would leave him naked to ridicule and shame and would put him under the control of those who knew his secrets....The numerous instances of suicides and nervous breakdowns resulting from such exposures by government investigation, press stories and even published research constantly remind a

> free society that only grave social need can ever justify destruction of the privacy which guards the individual's ultimate autonomy.[6]

As United States Justice David L. Bazelon notes,

> The information revolution means that I may find out everything about anything. But it also means I may learn more about you than you want me to know. Nor can I be sure that I will be able to control who knows what about me. Will we still be able to afford unfettered rights to speak and to know as the pace of technological development quickens?[7]

The Problem Restated: Personal Autonomy in an Information Society

The role of privacy in the development of the self is clearly complex and sometimes confusing. The problem exists wherever the public *perceives* that its privacy is being infringed upon. There can be no easy technocratic or legislative solution to what is essentially a human desire or need for a private life — especially when this need or desire is apparently put in jeopardy by fast-moving new technology. One can only hope that dialogue, tolerance, and understanding will help to alleviate the fears of the public and will inhibit some of the zeal and enthusiasm of the bureaucrats (in both private and public sectors) in their desire to "computerize everything."

The quest for greater efficiency leads to increased use of existing computer facilities. For example, the confidentiality of health records is a growing problem and concern. The widespread availability of data and information has led to a growing laxity in making such information available. One psychiatric social worker requested some pharmacological information on a patient from a hospital records office and reported the following: "I needed maybe one little piece of paper. Instead I was sent the entire medical *and* social services record, including notes of *anyone* who had treated the person. Much of the material was of a highly personal nature and had nothing to do with what I needed."[8]

The concern is not so much about the computer itself as about the consequences of linking together databases to form networks. It is one thing for someone to enter an office and open a paper file to extract some information on someone. The linking up of electronic data files means that information on individuals can be extracted without the requester having to be physically at the place where the information is stored. In fact, with distributed databases it may be difficult to know exactly where the data are — it is from the user's point of view sufficient that the data be accessible and retrievable.

The incorporation of large personal databases into communications networks presents a serious threat to conventional considerations of privacy. First, data that might previously have been considered nonsensitive can now become quite sensitive, because the correlation of such data with other information can lead to an accurate and detailed profile of the individual. Secondly, because such data can be easily transferred between databases, issues of security become complex and difficult. Finally, a great deal of personal data might be collected in the process of providing various services on a network: medical information in relation to health care delivery, financial information in relation to business activities, legal information in relation to the provision of legal services, and educational aptitude, ability, and performance information in relation to the provision of instruction.

The tendency of bureaucracies to acquire information is well known. The computer makes it easier and cheaper. The results have value to agencies that market consumer profiles, to police departments, to various agencies of the state that want to make sure, for example, that people are not cheating on their tax returns or are not collecting unemployment insurance payments when they already have a job. The positive value to epidemiology of having a total computer-based health record of the individual is offset by the possibility of such information becoming known to the wrong people or being distributed in a public way so that the individual is affected when he or she applies for a job, runs for public office, and so forth.

The proper and sensitive treatment of privacy, or, more correctly, individual autonomy is becoming an important issue and is creating a very real sense of unease during the transition to an information society.

To understand the issue of individual autonomy in a more concrete way, consider the following situation: suppose an individual decides to drive while under the influence of alcohol and is stopped by the police. In the morning the individual may wake up and say something like, "that was an idiotic thing to do — it was not me — or I was acting out of character." The individual will promptly pay the ticket or fine and just as promptly forget the whole incident. However, in the new electronic age, while the individual can engage in selective memory, the system cannot. Whether or not it is actually being done, the public *perceives* that more and more information about their public and private lives is stored and is easily retrievable at the push of a button.

In the development of individual personality, all human beings engage in some activities (some would call it private experimentation) that they would prefer to forget, and in others that they accept and enjoy and that become part of the image they present to the world. In a small town, the capacity for private experimentation is severely limited since privacy is limited. People are labelled at a very early age and generally adopt and accept the roles thrust upon them. To be "someone else" it becomes necessary to move to the big city where anonymity allows the individual to present a different persona to the world. To bring the point closer to home, try to remember just what information is included in your curriculum vitae and what is left out on the grounds that it could prove damaging to what "people out there think of you." The growing perception among increasing numbers of people that someone "out there" knows about them or can easily know about them is, in essence, the negative side to the "global village." The new information society presents a prospect of public knowledge of private acts; and the information can be stored in perpetuity. The small town is everywhere.

If experimentation is perceived to be an open file, what will be the impact on personality and character development? Will people become less willing to take risks? Will they become more rigid, more like one another? How will this shape the development of society? What will be the impact on the creativity and willingness to innovate that is the source of richness, diversity, and progress in Canadian culture?

In this regard, the restriction of privacy can have important political consequences, as noted by Justice David L. Bazelon:

> Potentially at odds with the free flow of information is the right to privacy. While the right to be left alone, to control information about ourselves, serves many purposes in a society that respects individuality, privacy has an important political dimension. By allowing the citizen control over private information and communications, freedom from surveillance, and spheres of action free of societal interference, privacy fosters the growth of the autonomous, free-thinking individuals necessary for self-government.[9]

How can legislation protect that which is central to the personality of each individual, the self-image? The power to control the self-image is what makes people individual or feel that they are individual. The loss of control over the sense of self (or the perception of loss of control over the sense of self) is the psychological nerve that is touched when privacy becomes an issue.

There are no easy answers. Because people — for a variety of reasons — have come to mistrust governments, they may see legislation and government pronouncements about protection of privacy as big government covering up what it cannot really accomplish anyway. Bluntly stated, legislation may be interpreted as part of the "big lie."

Consider the nuclear waste disposal problem caused by the generation of electrical energy by nuclear power. The more that various government agencies attempted to gloss over the problem and pretend that it could be easily solved, the more public suspicion and concern increased — especially when it became clear that the problem could not be easily solved. The public felt manipulated and duped. The net result was a distrust of government and an almost irrational fear of nuclear energy. Had the pros and cons of nuclear energy been adequately conveyed to the people from the beginning, it is likely that the nuclear debate would be carried on in a far less emotional way today.

Some Possible Solutions

Between the individual who says, "I have nothing to hide; I don't care what goes on my dossier nor do I care who reads it," and the individual who is so secretive that he or she is labelled clinically paranoid lies the majority of the population. Fears about privacy invasion arise when individuals feel they have lost control over what others know about them. Privacy legislation may be needed to restore to the individual the sense of control over personal identity.

Two different legislative approaches have been suggested. One approach is to decrease the amount of information that individuals have to declare on official forms. The recommendation is that this should be done even if there is a loss in efficiency to the system by this action. The question is posed in the following way: Which is needed more — more bureaucratic efficiency and closer social control, or greater privacy and individual control over social relationships? In Canada, one of the most efficient societies the world has ever known, it is difficult to consider the requirement for still more efficiency important — especially when that efficiency is gained at the expense of individual privacy or autonomy.

The other approach, suggested by Gardiner, uses legislation to give the individual control and ultimate authority over personal information that is stored in data banks. The basic issue in this approach is not so much what "private" information is available but how much control the person has over the accumulation and dissemination of this information.

For Gardiner,

> The basic principle should be that, except in extreme circumstances when a person has clearly demonstrated lack of responsibility and thus sacrificed some freedom, no one should have more control over

> the information about a person contained in such personal data banks than the person him/herself. Each of us is the world's foremost authority on our self.[10]

He goes on to contrast his position with the utopian view of a postindustrial future in which all information is available to all people at all times. "I share this noble vision. However, I have one qualification. When the information is about me, the principle should be some information to some people in some places at some times at my discretion."[11]

Both these approaches to privacy legislation appear reasonable and may be a good first step on the road to a solution. But when the basis for the public concern for privacy is fully considered, when the core of concern is found to be that well of hopes, fears, and desires related to self-image and identity, it is difficult to imagine any set of legislation that would, by itself, assure citizens that their right to privacy would not be abridged.

In any event, it is possible that legislation will not be needed. Fears about privacy invasion may diminish with the passage of time as people adapt to the fact that much can be known about them. People are remarkably resilient. The early fears and legislation surrounding the introduction of the automobile became dormant as people adapted to the new technology. Other technologies — the telephone, the radio, electricity — elicited similar reactions.

Such adaptation, if it occurs, will bring with it the need to make choices. When new technologies are introduced, trade-offs inevitably occur. Canadians have shown themselves willing to accept change and to make the choices that change forces upon them. After the industrial revolution, for example, they sacrificed certain personal freedoms for greater efficiency in the workplace. The benefits of an information society are likely to be great, but they will come at a price. People will be unwilling to adapt to life in an information society without a full and prior understanding of the benefits and costs involved.

Needed, then, is some form of national dialogue that openly, honestly, and truthfully deals with the complex area of privacy, the new technologies, and the trade-offs involved in adopting and adapting to the new technologies. Discussion and understanding can alone make possible the cultural adaptation that will ease the transition to an information society. The conventions surrounding privacy and autonomy may change; self-development and self-definition may take place in spite of possible intrusions by technology. Current notions and ideas surrounding privacy may change and adapt to the new social context provided by the information society.

Until now the mass media have concentrated on the almost magical wonders of an information era. Governments at all levels have been creating the conditions for rapid technological development and giving little attention to the social implications of the new information infrastructure. As noted in previous chapters, such an obvious issue as employment and working is only now being discussed in the context of an information society. Full discussion of the issues is needed to deal with the public's deep-seated and well-founded fears — many of them hidden even to the individuals who argue vociferously for one position or another.

The area of privacy and personal autonomy will be difficult to discuss in open meetings. Yet it is vital that such discussions begin now. If the issues are not sensitively and adequately dealt with, the casualties involved in adopting the new technologies could be great, and incalculable harm may be done to individuals and to Canadian society as a whole. The public must be treated as a full partner in the discussion of the trade-offs involved in the transition to the information society — to do otherwise would be to do the Canadian public a disservice and to put in question Canada's democratic institutions and our continuing progress as a democratic country.

The debate on privacy must begin now. By itself, legislation will not be enough. It will neither alleviate the fears of an anxious public nor assure its acceptance of change. But a full and fair discussion of the issues may lead to better legislation and to the understanding that makes adaptation to change possible. Only through understanding will we be able to remain in control of the changes now taking place and not be controlled by them. The case is clearly stated in a letter from the (then) president of France, Valery Giscard d'Estaing, to Simon Nora:

> The applications of the computer have developed to such an extent that the economic and social organization of our society and our way of life may well be transformed as a result. Our society should therefore be in a position both to foster this development and to control it so that it can be made to serve the cause of democracy and human growth.[12]

Chapter 8

Artificial Intelligence

What is Artificial Intelligence?

In recent years a combination of powerful new software techniques and substantial improvements in hardware capabilities has produced systems that perform highly complex tasks previously regarded as uniquely human. Such systems can understand and produce complex English text, play world class chess, make sophisticated medical diagnoses, help design very large-scale integrated (VLSI) circuits, and recognize and manipulate various objects. What these systems have in common is the ability to make autonomous and complex decisions and inferences. In many cases, the decision or inference rules are modelled after human experts and emulate their intellectual abilities and problem-solving skills. Although systems of this type can substitute for human experts, they are usually used as aids in applications that involve complex data and information analysis, such as large-scale software development, geophysical data analysis, and VLSI circuit design.

Artificial intelligence (AI) can be defined in a number of ways. It can be defined as the property of a machine capable of reason by which it can learn functions normally associated with human intelligence; or, as a science concerned with understanding the principles of intelligence and with building working models of human intelligent behaviour; or, as the part of computer science concerned with designing intelligent computer systems, that is, systems that exhibit the characteristics associated with intelligence in human behaviour — understanding language, learning, reasoning, solving problems, and so on.

The definition of AI has changed as the field has matured. The history of AI[1] is not that of an integrated discipline with a general methodology and a set of researchable areas. Progress to date has come from a number of areas.

The name artificial intelligence was put forward by one of the pioneers in the area, John McCarthy, in 1956. Although other names have been suggested, such as machine intelligence, cognitive simulation, theoretical psychology, experimental philosophy, and applied epistemology, the original name has endured.

The realization that machines could duplicate the functions of human intelligence came about in the 1940s.[2] Early computers were crude by contemporary standards, but their designers realized that their electronic circuits imitated certain processes in the brain. At the time, research workers in cybernetics (feedback) and neurology predicted that, in principle at least, it should be possible to build a computer that would approximate many of the abilities of the human brain. This electronic intelligence would have an enormous impact not only on industry but also on society as a whole. These visionary workers also realized that the computer would be a valuable new tool for exploring that greatest of scientific mysteries — the nature of the human brain.

In 1943, for example, Warren McCulloch and Walter Pitts made a theoretical study of neurons in the brain and suggested that they operated as binary (on-off) switches. They showed that a network of such switches could duplicate all the functions of symbolic logic. This was a surprising and important result, for it demonstrated that the simple on-off switches that made up the building blocks of a computer were capable of carrying out complex logical operations.

In 1948 Norbert Wiener published *Cybernetics*, in which he drew analogies between the mathematics of servomechanisms and the internal behaviour of biological systems.

By 1950 scientists were taking computer intelligence seriously enough for the British computer scientist Alan Turing to propose a test that would determine the extent to which a computer could be judged intelligent. Turing proposed the following: a person holds a conversation with some unknown entity by means of written messages. At the end of the conversation, the person is asked whether the unseen partner is human or not. If the person judges that a human intelligence was involved in the exchange and the unseen message writer is a computer, then the computer can be deemed intelligent.

In 1952 W. Ross Ashby's *Design for a Brain* explored additional mathematical models of the brain. By 1956 the theoretical implications of computers, neural networks, information, and cybernetics had been much discussed.

This was a pivotal year in the development of a number of ideas that, grouped together, could be termed AI. At Dartmouth College, in the summer of 1956, a small number of scientists met to talk about the work they were doing toward making machines behave intelligently. They came from disciplines such as mathematics, psychology, and electrical engineering, but all held a common belief that what is called thinking or reasoning could take place outside the human body. They further believed that the thinking process could be understood in a formal and scientific way and that the digital computer represented the instrument for demonstrating that process.

The four main actors in preparing for the conference were John McCarthy, then a professor of mathematics at Dartmouth; Marvin Minsky, then a Harvard junior fellow in mathematics and neurology; Nathaniel Rochester, manager of information research at International Business Machines' (IBM) research centre in Poughkeepsie, New York; and Claude Shannon, a mathematician at Bell Laboratories. These four collaborated on a proposal to the Rockefeller Foundation that said, "We propose that a two-month, ten-man study of artificial intelligence be carried out during the summer of 1956 . . . . The study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it."[3]

The Rockefeller Foundation provided $7500 for the endeavour and the initial four invited others to make up the proposed complement of 10. These included Trenchard More and Arthur Samuel of IBM, Oliver Selfridge and Ray Solomonoff of the Massachusetts Institute of Technology (MIT), and Allen Newell and Herbert Simon of the RAND Corporation and Carnegie-Tech (now Carnegie-Mellon University), respectively.

Several equally ambitious research projects were also initiated at Dartmouth to develop:

- a complex system of artificial neurons that would begin to function as an artificial brain;
- a robot that would build up an internal picture of its environment;
- a computer program to derive the theorems of Alfred North Whitehead and Bertrand Russell's *Principia Mathematica*;
- a chess-playing grand master that would also provide significant insights into the nature of human intelligence;
- a model of the brain's visual cortex.

However, by the early 1960s the optimistic mood of Dartmouth collapsed as it became clear that AI involved problems that were far more complex than anyone had imagined. The various projects proposed in 1956 failed to produce significant results and showed that the difficulties involved had not always been clearly understood. Efforts in machine translation, for example, exposed the subtleties and difficulties inherent in understanding natural language but produced little in the way of commercially attractive translation programs. In 1966 the largest American project in this area was terminated. Problem-solving also ran into serious difficulties when it was discovered that the "solution space" required (the number of possible alternative solutions that the computer would have to investigate) for any moderately complex problem, was far too large for existing computers and would involve excessive amounts of computer time.

By the end of the 1960s progress in AI had ceased. Funding for large projects had been reduced or cancelled and it had become difficult to convince university administrators and government policy makers of the importance of the topic. But AI researchers were also learning from their mistakes. To begin with, they realized their error in attempting to build a universal machine intelligence and in tackling problems that were too general in nature. Throughout the 1970s, research on AI concentrated on well-defined problems and on applications in carefully structured situations.

The 1960s also saw the development of important technical approaches that were exploited to advantage in the 1970s. These new techniques can best be illustrated by analogy to human problem solving. Faced with a difficult problem, a human being does not necessarily proceed in a strictly logical fashion and examine every alternative with the same attention. A person guesses and uses rules of thumb; a problem may be simplified and broken into smaller parts or the solution of a similar problem may suggest the strategy for a new approach. People also ignore certain details in favour of a global approach and juggle several factors at the same time.

AI researchers realized that each problem requires its own particular strategy and can best be tackled with the aid of heuristics (reasoning from past experience) or rules of thumb. Computers were designed to do several things at once, which involved parallel processing and time sharing. In addition, new programming languages were written that were better adapted to problem solving and AI work. When these insights and technical advances were combined with the more modest goals adopted by AI researchers, the field underwent a renaissance in the second half of the 1970s. This resurgence was also assisted by advances in the theoretical understanding of problems specifically connected with AI. In linguistics, for example, Noam Chomsky's theory of linguistic structures had a considerable influence on machine translation, question-answering machines, and the understanding of natural languages.

Even more important in implementing these new advances was the realization that AI systems must have a general knowledge of the world. Much of the human ability to deal with day-to-day situations comes from the vast store of informal knowledge that is human experience. Human beings know that day follows night, stones fall, shadows move with the sun, vegetables grow in the ground, and so forth. They know about people and society, about beliefs and actions, about recreation and daily work. Without any of this background information, a general conversation between two people would be impossible and few daily problems could be appropriately solved.

AI workers today recognize that computers must also be given a knowledge base. Without a knowledge base, even the fastest and largest of machines cannot understand the context of a conversation or solve the simplest practical problem. The programming of speech recognition, for example, relies on the computer's ability to match incoming sounds with the acoustic patterns of sentence fragments it has constructed. But this matching implies that the computer has anticipated and generated successive fragments of speech. To do so, a computer not only has to have a knowledge base of semantics and syntax, but must also have a way of recognizing the meaning of a particular sentence within an overall speech. This requires general knowledge concerning the topic of conversation.

Advances over the last five years can also be traced to evolutions in the computer itself. As more and more computing power is concentrated in a silicon chip, the computer becomes faster, cheaper, more powerful, and more compact. The result is that research groups even of modest size now have access to considerable computing facilities. Problems that once lay outside the capacity of a computer memory or took too much time to solve have become soluble. This process of electronic evolution is still accelerating.

By the late 1970s companies had also started work on the design and manufacture of computers specifically created for AI work, and the first applications of AI devices were finding their way into the marketplace. Microprocessors are on sale today that play championship chess, backgammon, and chequers. Industrial robots work in factories, machines are voice-operated, and barcode readers are found in many supermarkets.

Thanks to advances in computer design and new understanding about AI, knowledge bases, new programming languages, strategies, and heuristics, the discipline is developing rapidly. While most AI researchers are no longer willing to make generalized and optimistic predictions of the type that characterized the Dartmouth conference, they can point to successful applications and promising areas of study.

Fact and Fancy: Some Progress and Great Expectations

AI researchers are usually motivated by one of two objectives: (a) to understand the fundamental nature of intelligence, and (b) to develop computer applications of AI concepts that are useful and marketable.

Some of the subfields of AI include: problem solving; language understanding; expert systems; robotics, vision, and perception; and automatic programming and knowledge acquisition.

Problem Solving

The first successes of AI were programs that could solve puzzles and play games like chequers. Techniques that involved the ability to look ahead several moves and divide difficult problems into easier subproblems evolved into the fundamental AI techniques of search and problem reduction. Today programs play championship-level chequers and backgammon as well as very good chess. Some programs can improve their performance with experience. Unsolved problems in this area include the difficulty of giving machines capabilities that human players have but cannot articulate (like the chess master's ability to see the board configuration in terms of meaningful patterns). Thus far, however, AI programs have predetermined ways to solve problems. In other words, the way in which the computer will search for a solution to a problem is determined by the program itself.

Included in this subfield is logical reasoning by machine using programs developed to reason deductively from a set of facts. There are two problems of particular interest. One is the problem of how to get the computer to select the information it needs for a task – the computer must be able to differentiate between relevant and superfluous information contained in a large database. The second problem is how to integrate into the deductive reasoning process new information and procedures as they become available (which is particularly important in robotics). Programs have been developed that can "prove" assertions by manipulating a database of facts. For example, in the PUFF expert system diagnoses are produced by means of deductive reasoning from a set of facts and rules regarding pulmonary disease.

Language Understanding

Some of the earliest AI concerns were to develop programs to translate natural languages such as English, French, or Japanese; to develop computers that follow instructions posed in a natural language; and to develop computers that could acquire knowledge by reading textual materials, thereby autonomously building up an internal database.

Early failures in machine translation have led to a complete reorientation of the AI approach to language. It was discovered that literal word-by-word mechanical translation did not work. Currently, AI researchers are concentrating on building contexts for language understanding. Researchers have realized that vast amounts of common sense knowledge of the world, as well as expectations (based on context and situation) are necessary to understand language.

One of the great successes in machine translation was achieved by the TAUM group at the Université de Montréal. Working with a vocabulary of 200 meteorological and weather forecasting terms, a French-English translation system was developed that is in operation today. Since 1977 the system, named Victor, has been translating between three and four million weather-related words a year. Although it has an error rate of 15 per cent and therefore needs human translator intervention, the system does the work of over six human translators.

A later attempt by TAUM to use the same techniques to translate technical aviation manuals was not so successful. The size of the vocabulary was much greater and the system was unable to cope with the cross-references, illustrations, and detailed information contained in the manual. The TAUM aviation system was more advanced than the weather system and included some of the AI techniques that require an understanding of syntax, grammar, and the intent of the original text, plus an ability to rework the output in the second language. Unfortunately, the project was dropped when, after long delays, the TAUM system was only able to deliver translations at 18.3 cents per word, compared with the then current rate of 14.5 cents per word for human translation.

Machine translation projects are under way again in Canada as well as in Japan, the European Economic Community, and the United States. It is only a matter of time before improved techniques and reduced hardware costs make machine translation a cost-effective alternative to human translators.[4]

Expert Systems

Expert systems are a significant area of progress for AI. With over 40 expert systems now in use in laboratories or in industry, the emergence of expert systems represents a victory for AI and for those researchers who argued for AI, not as a general problem solver or general intelligence machine, but rather as a tool for use in specific areas, with specific knowledge domains – in much the same way that human experts operate and behave.

Expert systems can provide consultation and advice in different areas of specialized knowledge, such as geology, engineering, and medicine, at a level equivalent to human experts in the field. They are capable of explaining their reasoning to help the human user accept or reject the recommendations or diagnosis proffered and to assist in locating errors and "debugging" the system's reasoning process.

Developing an expert system is an arduous and lengthy process. Much current research in this subfield is involved with the key problem of improving and automating the way in which expert systems acquire knowledge. The whole area of expert systems will be discussed in greater detail below in the section dealing with applications.

Robotics, Vision, and Perception

If one imagines the central processing unit (CPU) of a computer to be like the human brain, then AI requires input and output devices (computers have keyboard and video-display terminals or printers; a few allow voice input) similar to those possessed by people. For robots to become more adaptable and flexible in the work environment, they must be able to "see" and "touch" much as people do.

Although most of the thousands of robots used in industrial operations are blind and perform repetitive tasks, some can "see" through a television camera that transmits information to the computer. Processing visual information and pattern recognition are two very active and related areas of AI research. Programs have been developed that recognize objects and shadows in visual scenes; others can identify small changes from one picture to the next, as, for example, in aerial reconnaissance.

Automatic Programming and Knowledge Acquisition

Although programming is not an important aspect of human thought (unless one considers education to be a form of programming), it is a major area of AI research. The development of automatic programming has produced systems that can write computer programs either from a variety of descriptions of their purpose, from examples of input/output pairs, or even from descriptions in English of procedures to be followed. Progress in this area is currently limited to a few examples at a minimal level of complexity. Research in automatic programming may produce not only semiautomated software systems, but also AI programs that learn, in the sense that they can modify their own knowledge representations, databases, and, consequently, their responses to new situations.

Are researchers in AI being over-optimistic in their attempts to impart learning ability to computers?

In an interview with Deborah Sweitzer and Paul Schabracq, Dr Ira Goldstein of Hewlett-Packard, in Palo Alto, California, expressed the optimists' view of AI:

> I don't think that there is anything a person can do that cannot be done in silicon. There is nothing particularly unique to carbon, and that is the answer to the question "Do I believe that someday there will be devices that will have many of the capabilities that people have?" The answer is yes. I believe that if God created the universe then we are all physical things. I don't think He ruled out the creation of other physical things out of silicon with properties similar to us [*sic*]. It all follows the rules of the game that God set out, it's open to physical and scientific explanation. Any biochemical process going on in your head is duplicatable as electrons flowing on silicon.[5]

But substantial research problems in AI remain. These have to do with how knowledge of the external world is acquired, represented, and retrieved in the internal world of the computer. More formally, the research areas of AI are concerned with the following:

- How can knowledge be obtained from the external (physical) world?
- How can this knowledge be assimilated and expressed internally, that is to say, within a computer?
- How can knowledge derived from information sources (books and people) be expressed internally in a manner compatible with the knowledge obtained from the external world?
- How can these internal representations be manipulated to derive specific observations and generalizations?
- How can the system incorporating these representations determine and request specific additional information to enable it to perform the functions requested of it?

The following quotations from interviews by Sweitzer and Schabracq sum up the key problems in AI:

> The human is apparently a very superior problem solver, compared to anything else developed to date. If you ask, "Can you ever get a machine like a human in terms of general problem-solving capability?" I'd answer that it's hard to imagine it in the next two to three generations, plus or minus 100 years. (Charles Rosen, Machine Intelligence Corp., December 1981)[6]

> Knowledge acquisition is the critical bottleneck problem of all AI simply because if it's true that systems become more powerful by having more knowledge, then obviously the acquisition is the critical bottleneck . . . .Progress in knowledge acquisition depends heavily on progress in natural language understanding. (Edward Feigenbaum, Stanford University, December 1981)[7]

> In order to build truly intelligent programs, we've come to realize that we've got to simulate common sense reasoning. Reasoning that allows untrained people to perform well in the course of their daily lives, that is not in a specific knowledge-based area but in areas which use knowledge of the ordinary world — such as the physics that every 12-year-old understands before he takes a physics course, i.e., objects fall. (Nils Nilsson, SRI International, December 1981)[8]

An analogy might be drawn between the problem of knowledge acquisition in AI and the education of Helen Keller. Blind and deaf from the age of two, Helen Keller had very limited ways of learning about her world. Yet by the time she reached her early teens, she had become a very well-informed woman capable of understanding and discussing every aspect of life. To be able to do this, Helen Keller had not only to acquire knowledge about the world through a very "narrow channel" — her tactile sense — but also had to shape that knowledge into a model of the world that was congruent with that held by others. In a similar way, researchers in machine intelligence are confronted by the computer's inability to obtain, represent, and assimilate real world knowledge. Like Helen Keller, the computer is limited by its input devices, depending entirely on a human being to represent, encode, and program knowledge about the world.

A related problem is that of duplicating within the computer the underlying structures of the human mind that allow it to store, organize, and manipulate the information it receives, shaping it into an overall world view. In human beings, this world view, or model, serves as a point of reference in assessing new information, formulating a hypothesis, evaluating problem-solving alternatives, carrying on a conversation, and so on. One obstacle thwarting researchers' attempts to give this ability to a computer is the fact that computers do not have a genuine understanding of the data they manipulate. The relationships expressed by a computer, although simulating a real world situation and apparently indicating understanding, are abstractions of reality translated back and forth from one representational system to another, and each representational system is itself an abstraction. It is only through a program, and human programmer, that a computer is given the ability to communicate at all, since the rules and control strategies are the product of human capabilities.

Finding creative, implementable solutions to the problem of giving computers real world input and real world understanding is likely to be a long-term undertaking, because there is little knowledge of the analogous human process and a corresponding lack of models to structure the research. Partly in answer to these concerns, researchers have turned toward problem-solving in limited domains. Using "small worlds" allows relevant information to be formalized and encoded. This trend, which is sure to continue, can be seen in expert systems, natural language processing, and robotics. If it became possible to construct an accurate representation of the world in bite-size pieces, the resulting simulation would be adequate for many problem-solving purposes. The use of limited domain models is a built-in limitation that will define the kind and scope of problems with which machines can deal.

Applications of Artificial Intelligence

Universal product codes (bar codes), computer time sharing, chess-playing programs, pattern-recognition techniques in radar, geophysics, and seismic signal processing, and more, are all examples of applied AI. These systems work, are for sale, and represent a new development in computers. They mark a shift from computers as information processors to computers as knowledge processors, from computers that calculate and store data to computers that can reason and infer.

In the 1970s a number of those researchers trying to get computers to speak natural languages arrived at the same conclusions as expert-systems workers: by narrowing the domain to be talked about, a program could be given enough knowledge to hold a serious conversation. This approach is starting to pay off in one particular area: the use of natural language to interrogate existing computer databases. A team at the Stanford Research Institute (SRI) has written a program called Ladder that can respond to questions about the personnel and ships of the United States Navy. (The work is done for the defence department.)

At the University of Pennsylvania, home of ENIAC, the world's first all-electronic digital computer, researchers are making progress in getting their program to respond intelligently to questions about student records. They are giving it such abilities as: volunteering information that may have a bearing on the original request, explaining the background to the information it is providing, and recognizing implicit requests inherent in human dialogue.

But the real champion of commercial natural-language programs is Intellect, developed by Artificial Intelligence Corporation (AIC) of Waltham, Massachusetts. The program enables a user to interrogate a company's database directly, without having to ask a computer expert to translate the request into commands the computer can understand, or having to remember a complicated set of rules for getting at the information.

Intellect takes an English-language request typed in by a user, translates it into a form that reflects the peculiarities of the database, repeats this on the screen so the user can see the machine has understood correctly, and then summons up the information required. This feat requires knowledge about the user's intentions and the background to the request. In Intellect, that knowledge is provided by interrogating the database, often many times in the course of a single operation. Thus, if asked, "What are the average earnings of the company's salespeople in New York?" the program will check the database to determine whether "New York" is ambiguous or not. When it finds that there are two New Yorks, it will respond by asking the user if the city or the state is meant.

However, if Intellect is asked, "How do the average earnings of salespeople in New York compare with those of salespeople in Chicago?" it will check the database, learn that Chicago is a city, draw the conclusion that the New York referred to is also a city, and provide the desired comparison. Other typical requests that Intellect can handle include the following: "How many salespeople in New Jersey are over quota?" "How many of them are managers or supervisors?" "Their names?" "How many policy holders carry uninsured motorist protection?" "List the stores that have more than 20 employees and annual gross sales of less than $750 000."

Intellect is a practical commercial product because its structure means that there is no need to build a huge new knowledge base for each application. The knowledge is derived automatically from the database. Each new application requires only a lexicon of appropriate vocabulary (including, when necessary, company slang), which takes about two weeks to construct. Buying Intellect direct from AIC costs $50 000 to $75 000 for a permanent licence, plus a fee of $7500 for each lexicon that AIC draws up. Over 500 contracts for Intellect had been signed by early 1983. Customers include Ford, which uses Intellect to handle questions about which cars have met which environmental regulations; E.I. Du Pont de Nemours, which uses it to handle questions about sales and production of polymers and resins; and a bank in Rhode Island, which uses it to handle questions about its commercial loan portfolio.

Another success in AI is in expert systems (ES). The earliest ES was DENDRAL developed by Edward Feigenbaum of Stanford University. The function of DENDRAL is to interpret and generate plausible structural representations of organic molecules from mass spectrogram data. In Feigenbaum's own words,

> An "expert system" is an intelligent computer program that uses knowledge and inference procedures to solve problems that are difficult enough to require significant human expertise for their solution. The knowledge necessary to perform at such a level, plus the inference procedures used, can be thought of as a model of the expertise of the best practitioners of the field.
>
> The knowledge of an expert system consists of facts and heuristics. The "facts" constitute a body of information that is widely shared, publicly available, and generally agreed upon by experts in a field. The "heuristics" are mostly private, little-discussed rules of good judgement (rules of plausible reasoning, rules of good guessing) that characterize expert-level decision making in the field. The performance level of an expert system is primarily a function of the size and quality of the knowledge base that it possesses.[9]

DENDRAL has spawned more than 40 expert systems. The key to building an ES is the acquisition, representation, structuring, and retrieval of knowledge. Feigenbaum discovered that experts in any area carry around with them enormous amounts of specialized knowledge. The problem is to transfer that knowledge — most of which is implicit — to a computer program.

> The difficult task [in building DENDRAL] was to sit down with those human chemists, watch them work, ask them questions about how they made decisions — questions they weren't always able to answer

> in ways that would fit comfortably into a computer program — and then figure out some way of representing that knowledge, those rules of thumb, in a large database.[10]

The person who deals with these specialized problems is called a knowledge engineer. The knowledge engineer must spend a great deal of time with the expert to obtain and define the specialized knowledge. The problem is that the knowledge inside an expert's head is largely experiential and uncertain — mostly good guesses — rather than factual and systematic.

> Much [of the knowledge] is private to the expert, not because he's unwilling to share publicly how he performs, but because he's unable. He knows more than he's aware of knowing . . . But if a second party or even the expert himself, undertakes patient observation of that expert in the act of doing what he does best, the knowledge can be teased out and made explicit.[11]

Expert systems are those programs that provide knowledge and advice in a specific field, such as geology or medicine, at a level equivalent to an expert in that field. They are more than databases, since they can implement a model of the way an expert uses his knowledge, makes relationships among disparate bits of knowledge, and uses reasoning. In an expert system program, this information is made explicit and communicable to the user. Standard computer programs run algorithmic programs, which are completely defined step-by-step procedures, or lists of instructions for solving problems. Expert systems draw conclusions not only by calculation and logic, but also by plausible inference and rules-of-thumb (heuristics).

An expert system is usually programmed to respond to simple English phrases. The answer to a problem or requests for more information, including the methods by which solutions have been formulated, are all expressed in short phrases or complete sentences. The ability of the expert system to explain its reasoning process in a natural language is called "transparency." This feature permits the user to validate or reject the expert system's functioning. An important aspect of expert systems is that they not only provide accurate answers but also justify their answers in terms that make sense to the human user.

Expert systems are now being developed in biochemistry, genetics, psychology, business management, engineering, law, and in the design of computer programs themselves. These systems are used for:

- project planning, monitoring, tracking, and control;
- communication;
- signal analysis, command and control, and intelligence analysis;

- design, planning, scheduling, and control in construction and manufacturing;
- instruction, testing, and diagnosis in education;
- equipment design, monitoring, diagnosis, maintenance, repair, operation, and instruction;
- image analysis and interpretation;
- consulting, instruction, interpretation, and analysis in law, medicine, engineering, accounting, law enforcement;
- specification, design, verification, maintenance, and instruction for software;
- target identification, electronic warfare, and adaptive control for weapon systems.[12]

Table 8.1, abstracted from Sweitzer and Schabracq,[13] shows the names and types of selected expert systems now in operation.

Table 8.1. Some Expert Systems Currently in Use

Area of Application	Name of System	Researcher(s)	Description of System
Computer Systems	R1	J. McDermott (Carnegie-Mellon)	Determines whether the set of components another system comprises is complete; determines relations among the components.
	XSEL	J. McDermott (Carnegie-Mellon)	An extension to R1. Assists salespeople in selecting appropriate computer systems.
Computing	PSI	C. Green (Kestrel Institute)	Automatic implementation of programs specified through natural-language dialogue.
	LIBRA	E. Kant (Carnegie-Mellon)	Efficiency-analysis component of PSI system.
	PECOS	D.R. Barstow (Schlumberger)	Knowledge-based program synthesizer for PSI system.
Education	GUINDON	W.J. Clancey (Stanford)	A computer-aided instruction program that teaches students by eliciting and correcting their answers to a series of technical questions.
Engineering	DART	(Joint project of Stanford and IBM)	Diagnostic-assistance reference tool used in field engineering. Investigates the use of expert systems to aid in the diagnosis of computer-system faults.

Area of Application	Name of System	Researcher(s)	Description of System
	KAS	R. Reboh (Stanford Research Institute)	Knowledge-acquisition system. Computer uses existing systems to design other systems.
	SACON	J.S. Bennett/ R.S. Engelmore (Stanford)	Structural analysis consultant. Assists structural engineers in identifying the best analysis strategy for each problem.
	SU/X	H.P. Nii/ E.A. Feigenbaum (Stanford)	Identifies and evaluates moving objects (location, velocity, etc.) from primary-signal data.
Geology	PROSPECTOR	P.E. Hart/ R.O. Duda (Stanford Research Institute)	A geological consultant that evaluates sites for potential mineral deposits. Based on CBC (computer-based consultant), a system that diagnoses problems with electromechanical equipment.
	DIPMETER ADVISOR	(Project done for Schlumberger)	A system for analysing data from oil-well logs based on production-system paradigms.
Medicine	CADUCEUS	J.D.Myers/ H.E. Pople (Pittsburg)	Diagnostic consultant program for different problems in internal medicine. Formerly known as INTERNIST.
	MYCIN	E.H. Shortliffe (Stanford)	Diagnoses bacterial infections and prescribes treatment.
	ONCOCIN	E.H. Shortliffe (Stanford)	Designed to assist physicians treating cancer patients. Guides management of complex drug regimens.
	PUFF	J.C. Kunz (Stanford)	Analyses patient data to identify possible lung disorders.
	RX	R.L. Blum (Stanford)	Helps guide statistical analysis of chronic-disease patients whose case histories have been followed for a long time.

Area of Application	Name of System	Researcher(s)	Description of System
	VM	L.M. Fagan (Stanford)	Ventilator management system that uses physiological data from patients to help guide the physician in determining when to take a patient off the ventilator.
Science	META-DENDRAL	B.C. Buchanan (Stanford)	Uses mass-spectrometry data to induce rules about the behaviour of fragmented molecules.
	MOLGEN	J. Lederberg (Stanford)	Helps geneticists plan experiments involving structural analysis and synthesis of DNA.

One example of an expert system is PROSPECTOR, which helps geologists involved in mineral exploration by identifying the mineral deposits that are likely to be at a specific site. There are approximately 35 principal types of mineral deposits that are of economic and geologic interest. At present, PROSPECTOR has knowledge of nine of them relating to various classes of lead, zinc, copper, and uranium deposits. The user types in questions in simple English, supplying information that might be relevant about the prospective site such as, "there is galena," or, "there might be sphalerite." PROSPECTOR then begins to ask the user questions such as, "To what degree do you believe that there is evidence of metamorphism?" The user responds with an estimate of confidence ranging from -5 (certainly not) to +5 (certainly, yes). On the basis of the user's input, the system estimates the likelihood of various alternative hypotheses, determines the most likely one, and asks questions designed to verify or refute it. At any point the user can ask PROSPECTOR why it is pursuing its current line of reasoning. Typing "why" to the question of metamorphism stated above would result in the following reply:

> The evidence of high-temperature mineralization is discouraging for the prospective ore body being [a promising one]. However, if the high temperatures were due to subsequent metamorphism, then this discouraging evidence can be discounted.

PROSPECTOR has reached a level of performance that satisfies geologists. It asks appropriate questions and arrives at conclusions in a manner very similar to that of a human consultant. PROSPECTOR currently contains over 900 rules and is still in the developmental stage since it does not cover all the major types of deposits. This system is already credited with discovering a large deposit of molybdenum in the state of Washington.

An example of an expert system in a different field is the PUFF system recently developed by the Pacific Medical Center in conjunction with Stanford University. PUFF is used to diagnose and recommend treatment for pulmonary dysfunctions. Unlike PROSPECTOR, two distinctly different sources of data are used in PUFF. First, patient information such as age, sex, and number of pack-years of cigarette smoking are put into the computer. Then the patient is connected to an instrument/computer combination that acquires data on respiratory flow rates, volume, and so forth. The PUFF system produces diagnoses and prints them out in the normal medical summary form used by physicians.

Everything PUFF knows about pulmonary function diagnosis is contained in a series of 55 rules that have been developed in conjunction with medical experts and project engineers. One hundred cases representing a variety of disease states were chosen for study to develop these rules. As the knowledge emerged, it was turned into rules and added to the system. In the initial stages, the contributing expert was often surprised and frustrated by the occasional gaps and inconsistencies in the knowledge and by the incorrect diagnoses that were the logical consequence of incorrect rules and information. When these faults were corrected, an additional 150 new cases not studied during the knowledge acquisition process were used to test and validate the system. With this group of cases, agreement between PUFF and the human diagnostician was 90 per cent or better.

The key area in expert systems (as in all of AI) is the representation of knowledge, the retrieval of that knowledge, and the addition of new knowledge. The capacity to gain new knowledge or to learn is an important feature of an expert system and represents a basic element of intelligence. At present, expert systems can be said to learn only in a very limited or restricted sense: human experts working on a one-to-one basis with a knowledge engineer feed new knowledge and rules into the system. Developing expert systems is currently almost a cottage industry. It is labour-intensive, slow, and requires the use of highly skilled people. Knowledge is currently hand-entered into the machine. If it were possible to semiautomate, or even automate, the learning process, then there would be exponential growth in both the number and depth of expert systems, and in the accessibility and growth of knowledge in general. This will be one of the major areas of research work in AI for the next decade.

So successful have expert systems become that, in this area of once obscure research, whose long-standing concern used to be adequate research support, there is now a new concern: the loss of AI workers to industry. At the 1982 National Conference on Artificial Intelligence in Pittsburgh, new firms presented their products and tried to lure graduate students into this field. This trend marks the success of AI research and, while it may divert some researchers to commercial applications, it will ensure that intelligence of a sort will be embodied in machines and put to human use in the marketplace.

Some Implications of Artificial Intelligence

In the early days of computers, IBM became concerned that businesspeople would be frightened of machines that were touted as having the power to think. Intelligent machines, it was held, would threaten businesspeople and sales would decline. So the IBM sales force repeated the line that computers are essentially dumb machines that do only what they are programmed to do and will never do anything more. It appears that this statement is still partly correct. However, clever and intricate programming is beginning to produce some rather startling results.

What is frustrating to AI researchers is that once a usable product emerges, its roots in AI are ignored. When a computer succeeds in performing some task as well as a human, and the manner in which it operates is well understood, critics often claim that the activity involved is entirely mechanical and hence "not really intelligent." This has been summarized by Raymond Curnow in a saying called Tesler's Law: "AI today can be defined as a search for what machines *can't yet do*."[14] Once understanding, reasoning, knowledge representation, and meaning can be demonstrated in a program, a demystification of "intelligence" apparently takes place. Inexplicably, once it is possible to understand how the machine does its task, many people will immediately assert that the task does not involve intelligence at all. There appears to be an underlying fear of understanding intelligence in everyday terms. Perhaps a realization that intelligence can be demonstrated by nonhuman entities is so terrifying that it can by definition never be allowed to be achieved. It may be that the human race has staked a claim to the centre of the intelligent universe, and anything that threatens that claim will be ridiculed and immediately termed mechanistic and therefore not an example of "real intelligence."

Increasingly, the computer trade journals refer to the development of "smart" machines. How smart? To answer that question would require a widely accepted theory and understanding of human intelligence — something that philosophers and psychologists cannot produce.

Pamela McCorduck, in her book *Machines Who Think*, has given considerable attention to the question of the definition of intelligence and concluded that the concept is relative, not absolute. The dominant group in society generally describes itself as intelligent and considers all other groups to be of lesser intelligence.

In a later book she describes, in the third person, her understanding of intelligence and thought as follows:

> It began to dawn as she was comparing the arguments against thinking machines with the reasons given in the nineteenth century to explain why women could never be the intellectual equals of men. She found hilarious parallels between them. Initially, it only seemed like amusing lecture material to cite why women could never truly think — reasons of emotion, insuperable differences between men and women, no existing examples, and, yes, even ethical considerations — but by and by she began to sense that there was a larger truth waiting there. *Intelligence was a political term*, defined by whoever was in charge. This accounted for its astonishing elasticity. And for her the question — can a machine think? — became once more a nonquestion, a nonissue of no importance. [Emphasis in the original.][15]

Other commentators readily grant the possibility of true machine intelligence but question the extent to which machines should be used to replace people. Joseph Weizenbaum, a professor at the Massachusetts Institute of Technology (MIT), is perhaps the leading critic of the increasingly important role assigned to computers in modern society. His basic argument is that there is a difference between man and machine. Blurring that difference leads to exaggerated expectations of what machines can do and, as well, evades the human being's central place in nature. For Weizenbaum, the issue is not whether machines can ever perform like people but, rather, whether computers ought to perform tasks that could be performed by people.

Weizenbaum is the creator of the now famous ELIZA program. The program was designed to interact with a person in a psychotherapeutic situation. ELIZA plays the role of therapist. The following "conversation" between a young woman and ELIZA illustrates the technique of the program, which, like a human psychotherapist, encourages the client or patient to keep talking.

Patient:	Men are all alike.
ELIZA:	In what way?
Patient:	They are always bugging us about something or other.
ELIZA:	Can you think of a specific example?
Patient:	Well, my boyfriend made me come here.

ELIZA: Your boyfriend made you come here.
Patient: He says I am depressed much of the time.
ELIZA: I am sorry to hear you are depressed.
Patient: It's true. I am unhappy.
ELIZA: Do you think that coming here will help you to be happy?
Patient: I need some help, that much seems certain.
ELIZA: What would it mean to you if you got some help?
Patient: Perhaps I could learn to get along with my family.
ELIZA: Tell me more about your family.
Patient: My mother takes care of me.
ELIZA: Who else in your family takes care of you?
Patient: My father.
ELIZA: Your father.
Patient: You are like my father in some ways.
ELIZA: What resemblance do you see?
Patient: You are not very aggressive, but I think you don't want me to notice that.
ELIZA: What makes you think I am not very aggressive?
Patient: You don't argue with me.
ELIZA: Why do you think I don't argue with you?
Patient: You are afraid of me.
ELIZA: Does it please you to believe I am afraid of you?
Patient: My father is afraid of everybody.
ELIZA: What else comes to mind when you think of your father?
Patient: Bullies.
ELIZA: Does that have anything to do with the fact that your boyfriend made you come here?

The "interview" demonstrates the apparent reasoning power of the program. In fact, the program is designed to use key words and phrases and repeat them, or, when baffled, to say "Please elaborate," or "I don't understand," or "I understand," and so on. The program does not understand, but because of the specific domain of the therapeutic situation, it *seems* to understand.[16]

The reaction to Weizenbaum's program (also known as the DOCTOR program) surprised its author. A number of psychiatrists thought that it could be used in mental hospitals, thereby allowing more people to talk about themselves, unburden themselves, and gather insights into their troubled behaviour.

Weizenbaum was shocked at the rapidity with which people took to the ELIZA program and how they came to trust and confide in what is essentially a computer.

> Once, my secretary, who had watched me work on the program for many months and therefore surely knew it to be merely a computer

> program, started conversing with it. After only a few interchanges with it, she asked me to leave the room.[17]

The shock of such trust in a machine where a human being ought to be involved moved Weizenbaum to declare his position toward the rest of the AI community.

> . . . Briefly stated, [there are those] who believe computers can, should, and will do everything, and on the other side [there are those] who, like myself, believe there are limits to what computers ought to be put to do.[18]

Weizenbaum has emerged as the foremost critic of the unplanned expansion of AI into all areas of human endeavour. He is against the use of computers in the following instances:

- in war, to make killing easier and more efficient and to broaden the distance between the user of the program and the eventual enemy or victim;
- in situations in which the effects of computers and computer research are irreversible and where the side effects of the application, the research, or both, are not entirely forseeable;
- as a substitute for a human being in an area in which interpersonal respect, understanding, and love is needed.

It is the latter case that brought Weizenbaum into the debate created by his ELIZA program. Thus he rejects the proposal that computers be used as therapists — not because they cannot do the job, but because to do so would be immoral. Even though the troubled person may derive benefits from interacting with a computer, and even though a human therapist may not be available or affordable, Weizenbaum would reject the use of computers since their use, while yielding benefits, represents a machine intervention where human intervention is morally necessary.[19]

Pamela McCorduck responded to this point, by drawing a parallel with the great debate that emerged when drug therapy was introduced in psychiatry with positive results.

> Never mind that drug therapy really relieved a person's distress, didn't take as long by far, and didn't cost as much by a long shot. Therapeutic drugs wouldn't unearth the root problem, said the critics, they would only mask the symptoms.[20]

She goes on to note that drugs (like machines) work and actually help to lessen the amount of pain and suffering in human society. In many instances we do not know how or why certain drugs work, but the fact that they do places a heavy burden on those who say that there should be no intervention with drug therapy when a human therapist may achieve similar results, albeit over a longer period. With millions of aspirins being consumed every day, and with a less than complete understanding of how aspirin relieves pain, people still think that aspirins should be used. McCorduck believes that computer therapy — if it works — should be pursued. She implies that it is new and therefore Weizenbaum rejects it. For her, since it is new, it should be cautiously explored.

The questions raised by Weizenbaum arising from the ELIZA program go to the heart of AI research (although ELIZA, developed in the late 1960s, is said by many not to be "truly AI" and, in any event, is primitive compared to current programs).

More and more scientists in the field are coming to believe that computers can exhibit intelligent behaviour and that the prospect of a future with intelligent machines is indeed exciting. What is really staggering is the realization that computers can be, and are being, taught to reason, even if on a primitive plane. Machines can, and are, being instructed to learn from their own experiences and to make decisions based both on those experiences and on the vast body of knowledge they store. Machines will probably take on some of the important work now done by doctors, lawyers, teachers, and journalists.

This raises questions as to the role of computers in dislodging human beings from the centre of the intellectual universe. Knowledge is power and the computer amplifies that power.

A front-page story in the *Globe and Mail* entitled "Computer to Sound Battle Cry"[21] notes that the United States defence department is considering the development of a computer that can plot battles as skilfully as human generals. Its program would include "judgemental ability" that will let it make decisions about the movements of troops and weapons and constantly update orders based on the results. The first computer-general could take a command by 1990, according to a proposal presented to the Pentagon by TRW Defence Systems of Redondo Beach, California. While it will not be a "failsafe" device (failsafe is the name of a human procedure for ordering missile launches), the computer will order weapons to the battlefield without the approval of human commanders.

Weizenbaum's concerns about computers designed for the taking of human life have been superseded by events. Rapid developments in AI have led to the fear that machines could eventually become autonomous. In other words, machine decisions could either supersede or take control over human decisions.

> "That's not the danger," says Daniel Bobrow of Xerox. The real danger is that people will get to be more and more dependent upon the machines. "If you have an intelligent machine performing a function, the problem will arise when there is a new situation for

> which the machine is not prepared, and it doesn't understand the extra options not in the system. Then, the machine's dependence is what becomes a threat to us . . . .To the extent that we give responsibility to computer programs, we are fooling ourselves. We mustn't give machines authority without responsibility. We have to recognize that the computer program is an intermediary. When we say, 'The program said to do it,' or, 'The computer fouled up,' that's an excuse nowadays. The people who put in that computer system are the ones who are responsible. That's the danger of too much anthropomorphism. We will find ourselves powerless. Suppose we pull the plug on that machine? The program's still around. Someone can take it and run it on another machine. Then we will have no recourse."[22]

The questions continue: Could intelligent machines take over in a more direct way, seizing control of society, becoming digital dictators and enslaving mankind? Such questions make AI scientists nervous, partly because there is the possibility of sensationalism in even the most cautious answer, and partly because no one knows.

> "There's no reason to assume that we would ever wire together all our various intelligent machines performing their various tasks into one giant intelligent machine," answers Nils Nilsson of S.R.I. International. "There's no reason to assume we would want to do so." And yet, the argument goes, if computers will soon program other computers, isn't it possible that intelligent machines will beget ultraintelligent machines and so on? This question implies that if the machines were to take over, they would have to be smarter than humans. And that is an idea thoroughly repugnant to some people, who see man as the ultimate peak of earth's evolutionary struggle. On the other hand, some artificial-intelligence researchers wonder whether it is absolutely certain that man is now and always will be unique. "There are people who think that evolution has stopped and there can't be anything smarter than human beings," says Marvin Minsky of M.I.T. "But why should that be the case?"[23]

Edward Fredkin, a professor of electrical engineering at MIT, makes light of the major philosophical question underlying developments in AI: that human beings, in the future, may be surpassed by machines that behave in more intelligent ways.

> Humans are okay. I'm glad to be one, I like them in general, but they're only human. It's nothing to complain about. Humans aren't the best ditch-diggers in the world, machines are. And humans can't lift as much as a crane. They can't fly at all without an airplane. And they can't carry as much as a truck. It doesn't make me feel bad. There were people whose thing in life was completely physical — John Henry and the steam hammer. Now we're up against the intellectual steam hammer. The intellectual doesn't like the idea of this machine doing it better than he does, but it's no different than the guy who was surpassed physically. So the intellectuals are threatened, but they needn't be — we should only worry about what we

> can do ourselves. The mere idea that we have to be best in the universe is kind of far-fetched. We certainly aren't physically.
>
> The fact is, I think we'll be enormously happier once our niche has limits to it. We won't have to worry about carrying the burden of the universe on our shoulders as we do today. We can enjoy life as human beings without worrying about it. And I think that will be a great thing.[24]

Hubert L. Dreyfus, a philosopher, has attacked the notion that AI can ever be achieved. His book *What Computers Can't Do: A Critique of Artificial Reason*[25] contains many allegations, some of which have now been superseded by events. One of his famous assertions was that computers would never be developed to such a degree that they could play advanced chess. Events have proved him wrong, and in a widely publicized chess match Dreyfus himself was beaten by a computer.

However, Dreyfus, as a philosopher, presents some interesting ideas on the creation of true AI:

> Everyone senses the importance of [the computer revolution] but we are so near the events that it is difficult to discern their significance. This much, however, is clear. Aristotle defined man as a rational animal, and since then reason has been held to be of the essence of man. If we are on the threshold of creating artificial intelligence we are about to see the triumph of a very special conception of reason. Indeed, if reason can be programmed into a computer, this will confirm an understanding of the nature of man, which Western thinkers have been groping toward for two thousand years but which they only now have the tools to express and implement. The incarnation of this institution will drastically change our understanding of ourselves. If, on the other hand, artificial intelligence should turn out to be impossible, then we will have to distinguish human from artificial reason, and this too will radically change our view of ourselves. Thus the moment has come either to face the truth of the tradition's deepest intuition or to abandon what has passed for an understanding of man's nature for two thousand years.[26]

Thus the eventual success or failure of AI will bring profound changes in self-perception. It will either finally affirm mankind's place at the centre of the intellectual universe or it will forever remove mankind from a long-held egocentric view of the universe.

Although Jacques Ellul cautions that "trend is not destiny," trends in hardware and advanced software development raise fundamental philosophical questions. If computer capabilities have developed to such a degree over the past 40 or 50 years (with the majority of developments occurring within microelectronics over the past decade), what are the implications for society and culture in the future?

If AI is truly in its infancy, at the level of the Wright brothers' first crude attempts to create a flying machine, then the possibility of developing an artificial mind is a matter of time, effort, and patient experimentation. This achievement, when and if it appears, will surely rank in importance with the splitting of the atom.

It would mark a new departure in the actions, culture, and self-perception of the human race. One thing that sharply distinguishes human beings from the rest of nature is their highly developed capacity for thought, feeling, and deliberate action. In some animals limited examples of this capacity may occasionally be found; but the fully developed idea and reality of what is termed the mind is unmatched elsewhere in nature.

Of course, to develop a true machine mind would involve notions of consciousness and an extremely diverse class of perceptions and sensations such as tickles and aches, mental images, emotions, memory, expectations, desires, beliefs, motives, choices, and actions. And what of the Freudian notion of the unconscious? Can it also be reproduced in a machine, along with repressed desires?

McCarthy, the man who popularized the term AI at the 1956 Dartmouth conference, was asked whether a truly intelligent learning machine could be built à la science fiction. McCarthy answered in the affirmative. When asked why he holds this view he answered:

> The alternative is to say that there is an area of nature that is not reachable by science. And nothing in the history of science supports that hypothesis.[27]

There comes a point at which discussions of this sort are best left to theologians, psychologists, ethicists, and philosophers. The facts are that computers have moved from information processing to knowledge processing. The reasoning, inference, and "fuzzy thinking" normally associated with human beings can now be found in any of the more than 40 expert systems now in use. AI is a fact of modern life. It will not go away. As the next section on the fifth generation computer system will show, AI will become part of all computer activities and will come to play an ever-increasing role in human affairs.

Although general-purpose reasoning machines have not yet been developed, programs that can reason have been. What will happen if and when the final goals of AI have been reached? "The appearance on earth of a nonhuman entity with intelligence approaching or exceeding mankind's would rank with the most significant events in history. Although human beings cannot possibly imagine the full consequences, the effects on technology, science, economics, warfare — indeed, on the whole intellectual and sociological development of mankind — would undoubtedly be momentous."[28]

The Fifth Generation Computer

Despite dramatic changes in hardware and software, the basic design of computers has not changed since the 1940s. The general design is based on the work of John von Neumann, a computer pioneer and mathematical genius. Current computers operate in a serial or sequential way. Computers have become more powerful over the years in a number of ways — one of which is to increase the sequential activity of the machines. Supercomputers today, based on the von Neumann design, can operate at 250 million instructions per second. This is about 10 times as fast as the fastest commercial computers available.

The design philosophy underlying the von Neumann machine was based on making systems of maximum simplicity with minimal hardware, capable of efficient processing using elaborate software programs (in von Neumann's day hardware was expensive, bulky, short-lived, and consumed a lot of power). Thus the sequential high-speed stored-program machine became the standard for the computer world.

A new generation of computers is now being designed that reflects substantially lowered hardware costs and the new uses for computers developed by AI applications.

In 1981 a consortium of Japanese firms announced their intention to design and build a new computer that is fundamentally different from the von Neumann design. It will operate on a parallel processing model (which some neurologists believe is the way the human brain operates). The new computer will be designed from the ground up to handle all AI applications. Rather than being a data-handling machine, it will be designed to store, process, and manipulate knowledge. In fact, the speed of the fifth-generation computer (FGC) will be measured in terms of knowledge instructions per second (KIPS).[29]

The FGC project was announced to the world at an international conference held in Tokyo in October 1981. The plans for the FGC — which are scheduled to be implemented over a 10-year period — were so ambitious that they caught most of the computer experts by surprise. Many of the international observers at the meeting (invited by the government of Japan) either remained silent, or said the FGC could not be achieved. Some said, however, that even if 50 per cent of the objectives were achieved, the world of computers and computing as we know it would be forever altered.

The Canadian government's science counsellor in Tokyo sent an unclassified cable to various federal departments, including the Science Council, dated 29 January 1982. The cable described the FGC project. It is interesting to note the language it uses, which differs markedly from that commonly found in diplomatic correspondence.

> NEXT GENERATION COMPUTER OR FIFTH GENERATION COMPUTER (FGC) IS COMPUTER WITH CHARACTERISTICS CLOSER TO HUMAN BRAIN CAPABLE OF NONSEQUENTIAL AND PARALLEL PROCESSES . . . FGC IS SCI. FICTION TYPE OF COMPUTER WHICH WILL ASK YOU FOR SPECIFIC INFO WHEN YOU GIVE INSUFFICIENT OR PARTIALLY INCORRECT INFO . . . 300 PERSONS FROM ROUND THE WORLD [INVITED] AND INCLUDED BIG DELEGATION FROM IBM WHO WERE CLEARLY IMPRESSED WITH JPN APPROACHES EVEN THOUGH THEY ARRIVED HERE VERY SCEPTICAL . . . VERY GREAT IMPORTANCE IS ATTACHED BY GOVT TO FGC WHOSE CENTRAL AIM IS BROADER THAN ARTIFICIAL INTELLIGENCE AND IS TO DEVELOP COMPUTERS WHICH DO NOT/NOT NEED PRECISE PROGRAM WRITTEN TO USE THEIR FULL CAPACITY. THEY WILL ACCEPT IMPERFECT, PARTIALLY CORRECT SPOKEN COMMANDS, SHOULD BE ABLE TO MAKE INFERENCES AND REASON.

To give the reader some idea of the ambitiousness of the project, some of the key elements of the FGC — the basic application systems, basic software systems, advanced computer architecture, and computer network architecture — are described below.[30]

Basic Application Systems
The basic application systems include a machine translation system, a question answering system, an applied speech and understanding system, an applied picture and image understanding system, and an applied problem-solving system.

Machine translation system: The goal of the machine translation task is to be able to translate automatically from Japanese to English (later to other languages) and vice versa a wide range of written materials encompassing a vocabulary of 100 000 words. The translation must be 90 per cent error-free, the remaining 10 per cent to be completed, where necessary, by a trained human translator. As well, the entire translation process must cost less than 30 per cent of the cost of a purely manual translation.

Question answering system: The question answering system will be a facility that in various specialized fields will be able to respond to queries as would an expert in the field. Each field will have its own knowledge base. The target system must be large enough to accommodate some 5000 words and some 10 000 rules of inference. The system will understand rudimentary principles of conversation so that it can ask the user to specify further information as necessary. It will function in such specialized fields as computer-aided design and decision support systems. Later, it will be used as an advanced form of the expert systems now available to answer questions in medicine, chemistry, and other technical fields.

Applied speech and understanding system: The applied speech and understanding system has three goals: first, the development of a phonetic typewriter that can handle 10 000 words and analyse their meaning sufficiently well to make simple corrections and generate comprehensible sentences. Second, a speech responding system with the same word capacity, but aimed at natural conversation. And third, a speaker identification system capable of identifying several hundred different speakers from short samples of their voices.

Applied picture and image understanding system: The goal of the picture and image understanding system is to design a database capable of storing 100 000 pictures or images; the time to store both a picture and its abstract description must be only a few seconds; the retrieval time should be on the order of 0.1 seconds. The pictures discussed here may be such things as charts, engineering drawings, architectural views, medical x-rays, or satellite weather pictures, and the aim is not only to store them, but to be able eventually to process the information they contain.

Applied problem-solving system: The applied problem-solving system has two goals: to produce a system capable of solving mathematical problems; and to produce a system capable of playing games such as chess or the oriental game of "go" at very advanced levels.

Basic Software Systems

This category includes three areas: knowledge-base management system, a problem-solving and inference system, and an intelligent interface system.

Knowledge-base management system: The goals of the knowledge-base management system are:

- to build a knowledge base containing information from several different fields of expertise, either centralized or distributed, that incorporates learning mechanisms based on inductive inference, and is successfully linked to a logical inference system;
- to build a system capable of storage and retrieval of knowledge consisting of 20 000 rules and 100 million data items, with each item having on the average some 1000 words of data.

Problem-solving and inference system: The goal here is to produce an inference machine that handles syllogistic or if/then sequences of reasoning. At present, computer capabilities are assessed in terms of millions of arithmetic operations per second. The FGC plan is to build machines that will handle millions of logical inferences per second.

Intelligent interface system: The goal of this system is to provide system software backup. Its ultimate purpose is, as before, to eliminate the language gap between the user and the computer, whether the gap is caused by the difference between natural language and computer language, or by the difference between speech or image data and the keyboard input characteristic of current machines. The natural language and speech system should be able to:

- handle a vocabulary that includes common and technical terms relevant to the computer and information processing itself, and at least one other branch of scientific or technological knowledge;
- adapt itself to communication with unspecified speakers;
- produce speech output in both Japanese and English;
- process speech input and output on an almost real-time basis, that is, almost as quickly as required by the normal tempo of speech and hearing.

The picture and image processor should:

- permit a mechanically smooth interaction with the visual data;
- handle pictures at least as complicated as medium small-scale machine drawings and medical photographs;
- process pictures rapidly enough to allow a smooth man-machine interface.

Advanced Computer Architecture

The hardware goals of the FGC involve the production of a machine about 10 000 times more powerful than current commercially available machines. Much of the improvement is expected to come from the high degree of parallel processing planned for the new computer architecture.

Included in the FGC are six new types of computers to perform the following tasks: logic programming; a linking of functions; relational algebra; abstract data support; an advanced von Neumann computer (based on VLSI technology with up to 10 million transistors per chip) to link with conventional computers; and a data flow machine to be the central computer of the entire system. This latter machine is the parallel processor or non-von Neumann machine discussed above.

Computer Network Architecture

This area aims at developing methods of combining computer and communication technologies to make loosely coupled networks of physically separated computer systems. This challenge includes the standardization of network architecture: conception of a unified protocol spanning a variety of machines, terminals, public and private networks, and data types; development of an operating system for distributed functions; development of techniques for the coding, production, and verification of protocols; development of multimedia processing techniques for data, voice, picture data, and so forth; development of techniques for high-speed transmission interface, communication and control, and encryption; and development of linking technologies for optical fibre and satellite communication systems.

The list of research topics embodied in the FGC project could go on and on. It includes new and improved peripherals and memory. The FGC will have the ability to make inferences. Instead of manipulating data or words, it will process knowledge — writing its own programs, deciding for itself which steps to take to solve a given problem, automatically retrieving information from a library, and deducing rules on its own from sets of facts. The computer will then be capable of applying its findings to solve problems that human beings may not know about.

Above all, the FGC will be the ultimate "user-friendly" machine. It will be tolerant of people, accepting ill-defined problems (in the form of spoken language or free-hand sketches) and presenting the answers in a manner people can easily understand.

If the FGC project succeeds, it will change the way people use computers. First, it will allow anybody to use a computer without any training. Second, it will accelerate the trend toward the "global village" by providing acceptable low-cost machine translation of foreign languages. FGC technology will also provide very large databases that are easily accessible. It will lead to the development of completely automated systems in manufacturing and services.

Another spin-off of the FGC is the further development of expert systems. Earl C. Joseph of Sperry Univac is of the opinion that FGC techniques applied to expert systems will serve as "people amplifiers." This will lead to such people amplifiers as a "book on a chip," a "teacher on a chip" and a "doctor on a chip." FGC developments will give people direct access to their own expert systems.[31]

It is expected that a FGC will be able to think, make judgements, and sense its environment in much the same way that a person does.

- It will be able to see and judge the dimensions and shape of objects, and distinguish colour. It will also be able to accept spoken requests and give its results in natural language.
- It will have the ability to propose appropriate methods of solving specialized problems. For example, if supplied with the medical history of a patient, it could consult its reservoir of medical information and advise a physician on the precautions and possible treatment of the case in question.
- When a user states his final objective and outlines a working process, the computer will be able to program itself to achieve that objective.
- It will be able to detect and remedy problems within itself.

It is difficult to find the appropriate words to state the daring and adventure embodied in the FGC project. The interested reader is encouraged to refer to the original proceedings in which the philosophy and strategies of the FGC are explained.[32]

One expert observer at the FGC conference noted that

> people who believe in the unpredictability of scientific progress and revolutions find a planned revolutionary project to be almost a contradiction in terms. But sometimes ideology has to give way to reality: the Japanese project is both well planned and revolutionary. It did not invent the concepts of logic programming, but it is certainly the first, and perhaps today the only one, which grasped the immense potential of this approach, and gathered the critical mass of resources necessary to utilize it on a large scale . . . .The eventual success of the project will follow not from the amount of money invested in it, nor from the number of people working on it, nor even from the individual excellence of these people. It will follow from the coherent vision of its leaders, the genuine enthusiasm that they generate, and from the promising path of research they chose.[33]

Another observer likened the FGC project to President Kennedy's announcement to put a man on the moon within the decade of the 1960s. The clearly stated goal led to the creation of enormous systems, new technologies, and finally succeeded in reaching the stated objective. This expert, an American, closed his report on the FGC by sounding a warning to United States policy makers:

> Our current position with respect to Japan in the field of computer technology is very much like our position with respect to the Soviet Union in the sciences before Sputnik. We hear of plans, of funds allocated for research, of growing numbers of trained personnel from a country which we regard as technologically behind us. All is ignored, until one day the world sees an unaccustomed bright dot move across the twilight sky and dip beyond the horizon. There is suddenly a great national furor about why we were not warned, reforms through the educational system, programs to translate Russian technical journals, and finally the commitment of huge sums of money for a ten year moon project in order to catch up. At that point we had to do more than catch up technologically; we also had to restore in the eyes of a sceptical world our credibility as a leader. Thus, our unwillingness to heed warnings from many sources resulted in the necessity of spending tens of billions of dollars for what we could have bought with a fraction of that had we acted earlier.
>
> It takes time to get a project conceived, funded, staffed, and moving. If all this by magic were to happen tomorrow we would be almost two years behind the Japanese.[34]

A Sixth Generation Computer

There are other routes to the development of intelligent computers. An interdisciplinary group of biologists, chemists, physicists, materials scientists, electrical engineers, and computer scientists are even now paving the way for the development of a new field called molecular electronics. Their goal is to replace the transistors and other devices of solid-state electronics with molecular functional groups, organic or inorganic, that are constructed to exhibit the appropriate electrical behaviour when hooked together in networks. The ultimate goal would be to produce a molecular computer. In this way tiny computers could be implanted in the human body. They could be used, for example, to restore sight to those who are now blind.

Researchers want to use a miniaturized television camera mounted on eyeglasses as the "eyes" of a blind person. In itself this is not a new idea, but the way it would be implemented is imaginative. A tiny molecular "chip" would convert the signals from the digital camera into a pattern of current pulses in an array of miniature electrodes implanted in the brain. The electrodes would be coated with a protein attached to cultured nerve cells. The nerve cells would grow into the brain to make the final connections with neurons in the visual cortex. A radical extension of this notion is the human-computer hybrid, in which the computational power of an implanted computer would tremendously augment a person's intellectual capabilities.

Of course there is the question of how to construct a molecular computer. One method is through genetic engineering or protein engineering. One idea is to generate new proteins not found in nature by altering the genes that control the structure and function of natural proteins. Ultimately it may be possible to learn the gene structure appropriate for proteins that act as enzymes to catalyze the production of molecules that can perform the electronic functions of a computer. The machine would be self-assembling and could even reproduce itself.[35]

It is clear that the final chapter on AI, advanced computers, and the move to an information-based society is not yet written. Doubtless this chapter and, indeed, this entire report will need radical updating before this decade is over.

Conclusion

The economies of Western industrialized nations appear to be prospering, yet many are plagued by severe unemployment. Economic activity in many sectors is high and rising, yet predictions of impending economic doom abound. Reports of plant closings appear side by side with announcements of new firms and new industries being created. Polls and letters to the editors of newspapers and magazines reflect both the public's uncertainty about and enthusiasm over the future of industrial society. For some, we are in the midst of "de-industrialization" and face the trauma of adjustment in internal and external economic affairs. For others, we are suffering the birth pains associated with the emergence of an information economy.

The acquisition, storage, representation, manipulation, and distribution of information has always been part of human activity. It is the essence of thought, education, communication, and language. The fact that these processes are increasingly being conducted by machines through networks based on computers and microelectronics is the new and powerful force to which human beings must adapt. Western society appears to be constructing a nervous system that is external to itself, but one that, through an intricate weave of electrical impulses, mirrors and amplifies human needs and knowledge.

In the transition to an information economy, change becomes the new constant. The pace of change today is unprecedented, and change itself has become a source of the stress that characterizes the uneasy eighties. This point was made in an earlier Science Council publication that dealt with the same subject:

> Human societies do not internalize change easily. In the past, the span of generations was available and usually sufficient. Today we do not have that luxury. Change itself is the new imperative. J. Robert Oppenheimer, father of the atomic bomb, once remarked: "One thing that is new is the prevalence of newness, the changing scale and scope of change itself, so that the world alters as we walk in it, so that the years of a man's life measure not some small growth or the rearrangement or modification of what he learned in childhood, but a great upheaval."[1]

Together these two factors — the prevalence of change and the dominance of the economy by information-related activities — combine to give the new information technologies the cumulative force of a transformative technology. The nature of their impact on the economy, society, and politics is difficult to predict, but it is safe to say that few areas will be unaffected. The preceding chapters have sketched the outline of the information society. The major points emerging from that discussion are these:

- The advent of microelectronics is rapidly and irreversibly leading to a major and fundamental transformation of western society, with implications not only for the nature and organization of the economic infrastructure, but also for the quality of life, social organizations, and relationships among individuals, private institutions, and governments.

- An information society will test and challenge traditional values and norms related to work, especially work as a means of meeting material and financial goals; an information society will involve a restructuring of the very concept of work and of the relationships between skilled and unskilled workers.
- The advent of an information society will bring about widely divergent changes in the kinds and range of goods and services being produced, marketed, and consumed, and of their costs relative to traditional goods and services; this will place new demands on industry while requiring a major reorientation of workers, institutions, and physical plants and production technologies.
- Although the transition to an information society will make the management of information required for commercial, industrial, consumer, and bureaucratic processes more efficient, it will also present very serious threats to personal and corporate privacy, which will require increasingly sophisticated legislative, regulatory, and technological safeguards; information technologies also raise the fundamental question of a possible change in long-standing notions of personal privacy.
- Whereas the industrial revolution appears to have been about the substitution of machines for human and animal labour, information technologies can be used to do many activities that formerly required human intelligence. Thus recent developments in the field of "artificial intelligence" signal continued and profound changes in our relationship to machines and technology, demonstrate future potential for continued reshaping of the nature and meaning of work, and raise fundamental philosophical and practical questions as to the nature of intelligence, consciousness, and the nature and place of our species in the universe.

The emergence of raw information, and, in its structured state, knowledge, as the basic resource and agent of change is the key to understanding the social implications of the microelectronics revolution. Information as a basic resource shapes all other resources and affects all human activities. Economists have known for some time that information has one very interesting characteristic: it is not reduced or lessened by wider use or sharing — rather it appears to gain in the process of distribution and exchange. Although resources such as primary materials and energy are, by comparison, scarce and subject to depletion, information and knowledge are inexhaustible.

This fact opens the possibility of social change on a vast scale. As John and Magda McHale have observed:

> The shift in resource base and technologies [to information] has thus changed many aspects of the older zero-sum game condition of society — in which one side had to lose if the other gained, as resources were inadequate to share. Human survival has become more a non-zero sum situation — success or gain are predicated more on the sharing of advantage, on all winning.[2]

The notions of global interdependence, planetary consciousness, synergy, and so on all come to mind. The reader can follow this line of reasoning to some logical and dramatic conclusions. For this writer it is enough to raise the following questions:

- If economics deals with the allocation of scarce resources among competing users, then what will be the theory of economics and the role of economists when material scarcity is removed as a constraint?
- The potential of abundance has long been a theme in political economy. How will societies adapt to change of this magnitude? If, indeed, the information society marks the end of material scarcity, then new theories and strategies for cultural advance and adaptation are desperately needed.[3]
- What will become of long-standing and culturally important concerns regarding the person, identity, and privacy? If the information revolution is as powerful and transformative as it now appears, then perhaps there will be adaptation and changed individual and social behaviour on such a scale that Western culture itself will be altered.
- Data, information, knowledge, and wisdom are all part of the same whole. Will people have the wisdom to constructively and creatively adapt to change? If societies can survive and prosper, then what will become of their man-made institutions that reflect the permanence and continuity of the past?

The uneasy eighties are a time of transition and uncertainty. A large part of the unease is due to the fact that, although people know that change is taking place, they have difficulty in knowing just what it all means. They are unable to measure the rate of change, to decide whether they are better off or worse, richer or poorer. We in the Western industrialized nations are experiencing change in the very underpinnings of our society, but we have not yet developed an adequate theory of change or tools for measuring its extent or potential. With information becoming increasingly important as the building block of our economy, one is tempted to call for the development of an "information theory of value." That such a theory can be conceptualized and made operational is not clear. What is obvious is that much of the change taking place in Western society is difficult to evaluate since the tools for measuring economic change and social wellbeing were developed during and designed for the industrial era.

The meaning of productivity, growth, innovation, value, and wealth are known and understood in an industrial context. In the new context of an information economy, new terms will have to be developed and others that are no longer relevant will have to be discarded. The early part of the Industrial Revolution was similarly a time of confusion and dislocation. It was only later, much later, that adequate theories came forward to explain the nature of the change. Following from the theoretical developments, came those ideas and tools for measurement that are necessary for planning, evaluating, understanding, and adapting. This writer is confident that new paradigms and theoretical developments will occur to help people understand and measure the contours of their changed economies and societies.

But the work that must precede understanding should begin now. The rate and magnitude of change are rapidly outpacing the complex of theories — economic, social, and philosophical — on which public and private decisions are based. To the extent that we continue to view the world from the perspective of an earlier, vanishing age, we will continue to misunderstand the developments surrounding the transition to an information society, be unable to realize the full economic and social potential of this revolutionary technology, and risk making some very serious mistakes as reality and the theories we use to interpret it continue to diverge.

The preceding chapters are an attempt to trace some of the problems and opportunities inherent in the rapid implementation of a transformative technology. It is hoped that the ideas and examples advanced in this study will be useful to those Canadians who are trying to formulate personal, corporate, and social strategies for dealing with the transition to an information society. But the story is still unfolding. Much has been suggested in these pages, but much more has been omitted due to limitations imposed by space and this writer's imagination. Readers are encouraged to fill in the blanks, and, letting imagination and creativity soar, discover for themselves some of the possibilities for Canada's future development.

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